PURPOSE OF THIS SERIES

This is one of a series of Technical Papers (see inside front cover) dealing with various aspects of the work of FAO Fisheries Division, Biology Branch, including the review of pertinent information on particular topics, to meet requests for assistance for presentation to technical and scientific meetings, etc. Extra copies can be obtained by application to:

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PREPARATION OF THIS DOCUMENT

This document was prepared as a part of a Technical Assistance Assignment by the Author as indicated in the preface. It is to be considered as the fifth appendix to "Report to the Government of the United Arab Republic (Syrian Province) on the Fishery Resources of the Inland Waters of Syria" Rep FAO/ETAP (1045 and 1045A), 1959. The Government translated the draft and published it in Arabic. The FAO Regional Office for the Near East at Cairo prepared the typescript for this English version. Lectures originally prepared at the request of the Department of Education of the Ministry of Agriculture for delivery in Agriculture schools are incorporated, to provide a basic text for use at the proposed Fishery Training Centre at Kaloat el Moudik.

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PREFACE

A knowledge of the fish fauna is a prerequisite for carrying out fishery investigations and development of fishery management programs. No recent nor complete work on the fishes of Syria was available and therefore this book was undertaken.

The first two chapters deal with the identification of fishes and descriptions of the 86 species which may possibly be found in Syrian waters. Chapters III through XIII were originally prepared at the request of the Department of Education of the Ministry of Agriculture as lectures to be given at the Agriculture Schools. However, since this did not prove feasible, the lectures are included here and the combined work may be used as a textbook at the proposed Fishery Training Center at the Kalaat el Moudik Experimental Fish Station. The last chapter of the book is a field and laboratory manual which gives the essential techniques and also has bilingual (Arabic-English) record forms.

In compiling this work the author has made free use of a great many books, pamphlets and papers and technical articles. To cite all the sources would have tended to defeat the purpose of a simple, concise training guide, hence no credit is listed for sources of data. Only at the end of Chapter II is a short list of taxonomic references dealing with Syrian fishes.

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THE FRESHWATER FISHES OF SYRIA
and their
GENERAL BIOLOGY AND MANAGEMENT

Chapter I

Fish Anatomy

A fish is a cold-blooded, backboned animal which lives in water, propels and balances itself by means offins, and obtains oxygen from the water for breathing purposes by means of gills.

There are over 40,000 kinds of fishes in the world. There are big and little fishes, short and long, thick and thin fishes. There are fishes with teeth and without teeth, with barbels and without barbels, with or without scales, and with blunt or sharp noses. There are fishes that live on the bottom of the lake, or at the surface, or in between, in rapid flowing mountain streams or in very slow running rivers, and in ponds, marshes and the oceans. They are adapted to nearly every kind of possible fish environment.

In Syria, at present, we may expect to find 86 different kinds of fishes. But before learning what these kinds are, and how to identify them, it would appear advisable to study a little closer this animal called a fish. In order to be able to classify the fish according to their kinds, it is necessary to know their parts and other things about them. Therefore the following pages will tell us some of the things we need to know before proceeding into the second chapter of this book on the identification of the Syrian Fishes.

The form of a fish is varied, as can be seen at any fish market. Generally, however, the body of the fish is boat-shaped, the head in the same line without a neck in most cases. The shoulder girdle is attached to the skull at the nape. The pelvic girdle may or may not be attached to the shoulder girdle below. The body is usually longer than it is deep, the greatest depth is in front of the middle, leaving in most species a compressed paddlelike tail, which is used to move the fish. There are, however, in addition to this basic form, several other recognized forms. There are fish flattened from top to bottom, like the rays; fish compressed from side to side, like the soles; long fishes, like the eels; ribbon-like fishes, the bodies long, but compressed from side to side as in the ribbon fishes; fishes that are globular, like the ocean lumpfish; large-headed fishes, like the blennies; and lastly, the very odd-shaped fish, like the sea horses.

The body of the fish is divided into three parts, the head, trunk and tail (Fig. 1). The head is generally considered to end at the gill opening; the trunk extends to the end of the body cavity, usually to the vent; the tail completes the body. The body is covered first of all with a layer of skin. Unlike the human being, the skin of the fish is made up of living cells. These cells also excrete a mucus or slime which aids the fish in protection against disease, in moving through the water and in protecting it against rapid changes in water content of the body.

Beneath the skin is a layer of scales (Fig. 2) in most fishes. But here again there are fishes with no scales, or with a few bony plates, or with spines and prickles. The principal function of the scales is protection. The very early primitive fish had heavy armour plate, but gradually these have been lost. When a fish is born it usually has no scales. In the skin are scale buds which very shortly after birth begin to grow and form the scales. The number of scales on the fish remains the same throughout its life. As the fish grows the scales grow. This fact is quite useful to the workers studying the growth of fishes, because in the temperate zones of the world growth ceases for a period during the winter, and this stoppage of growth is shown on the scales. By observing under the microscope the number of interruptions in growth, the age of the fish can be determined. Also by making measurements of the distance between the marks it is possible to tell how long the fish was at the various years of its life.

Figure 1. Topography of Spiny-rayed fish, showing location of parts, and how measurements are made

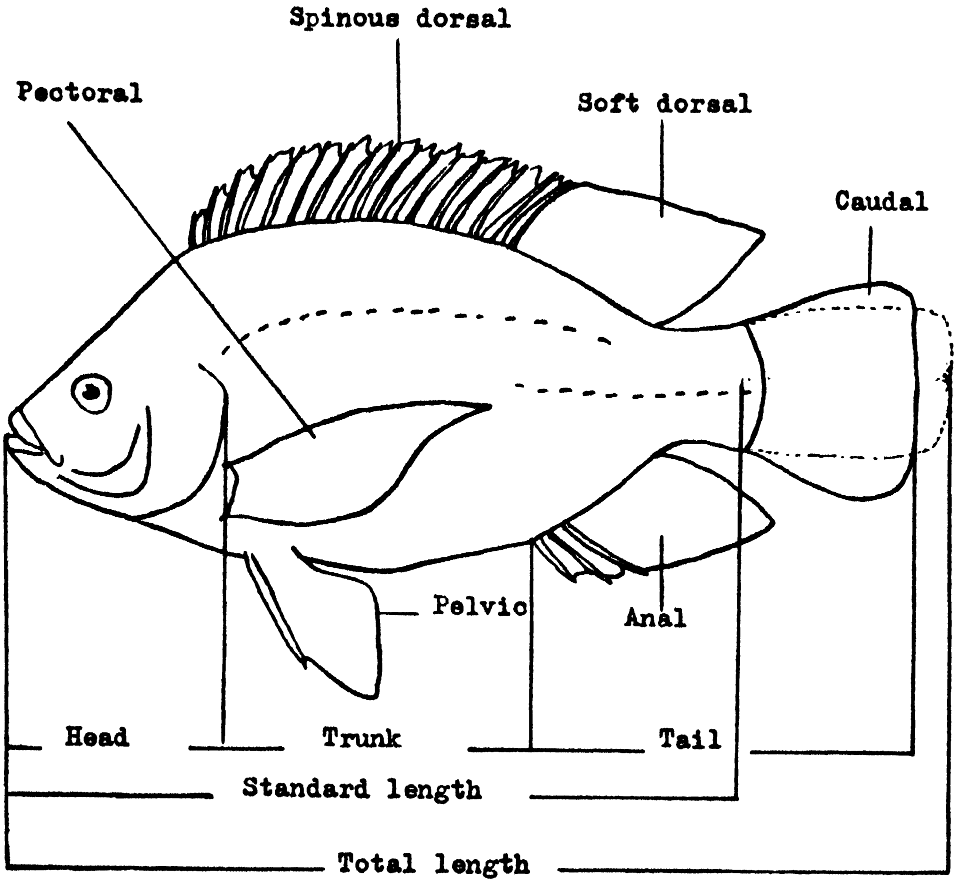
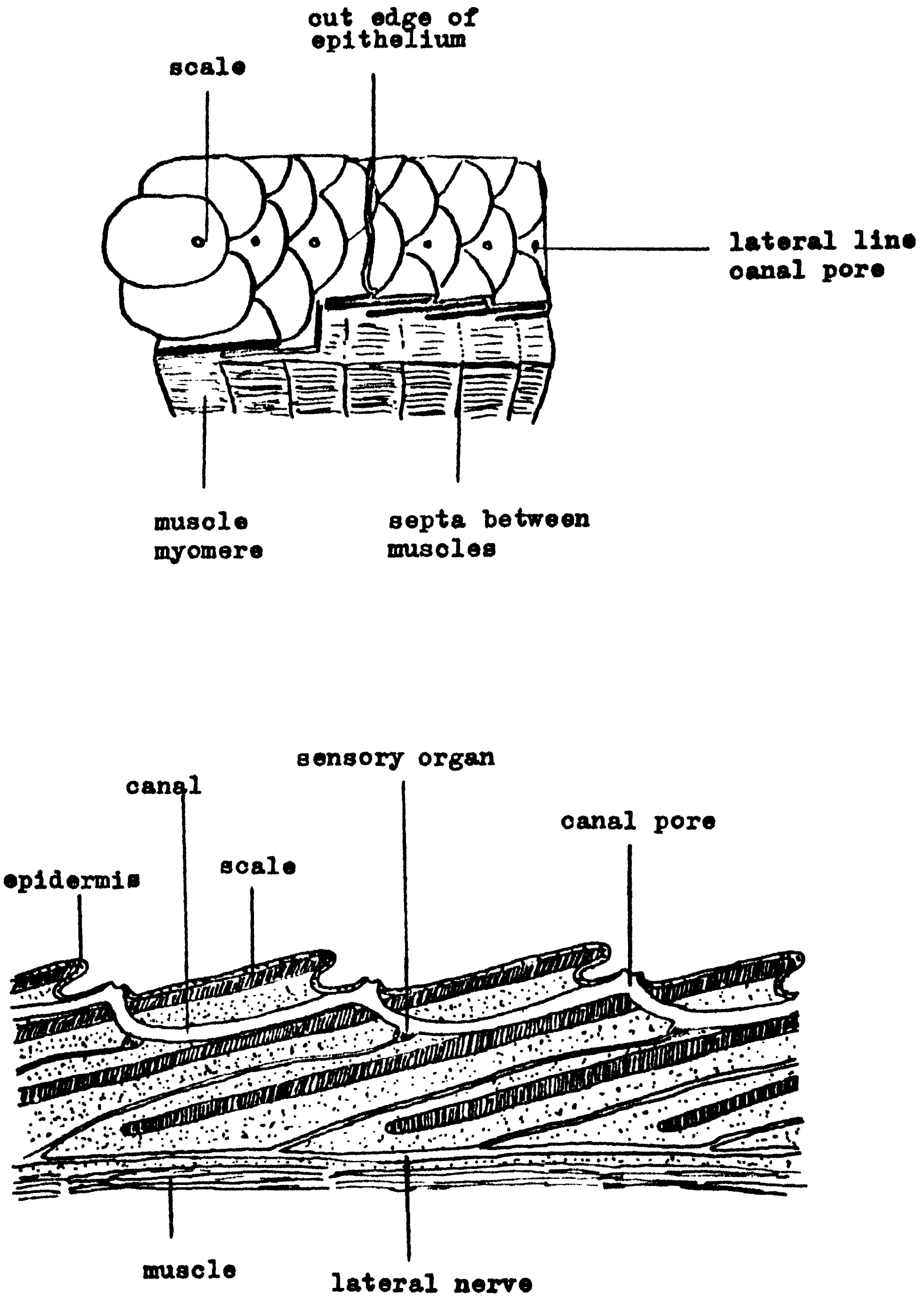


Figure 2. Fish scales



(Redrawn from Storer)

Scales found on fishes today can usually be classified in four forms -- Ganoid- platelike and not overlapping, laid side by side like bricks, such as are found in the garfishes; Placoid- small scales with projections or hooks, and covered with enamel very similar to human teeth, like on some sharks; Ctenoid- scales with small toothlike projections on the exposed part of the scale; and Cycloid- smooth scales with concentric rings only (Fig. 3-4).

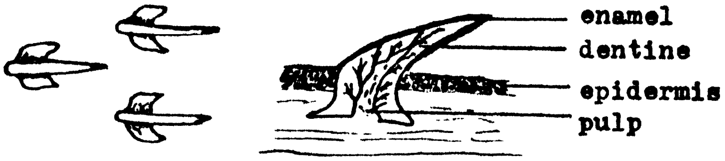
The color of a fish is due primarily to two substances contained in the skin -- chromatophores and guanin (Fig. 5). Guanin is a crystalline excretory product found in the skin, scales, swim bladder and silver layer of the eye. The crystals of guanin may occur in separate capsules or may be free in the skin, or be combined with the true color producer cells or chromatophores.

The guanin crystals and scales add to the iridescence seen in the fish, but are not really true color producers. They reflect and refract light to give various shades and hues.

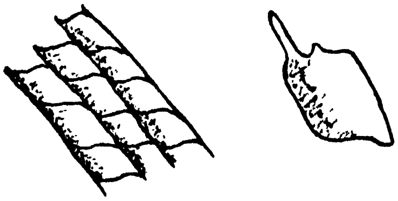
The true color cells or chromatophores contain the true color pigments. The pigments found in fish are black, red, yellow and blue. The chromatophores each contain only one color, and the fish can control the amount of color showing in each cell. It can shrink the pigment into a tiny spot or let it expand into the many arms of the pigment cell. Fish to a limited degree are capable of changing color patterns of their bodies. In going from dark to light backgrounds, the backs of the fish can become shades lighter. When travelling in weedy areas, they may become barred or broken patterned to better blend with their surroundings. Most fishes have some color, but in some caves there are certain species of fish that are colorless because they live in the absence of light.

The stimulus for coloration and change in color appears to be due to sight. Blind fish do not change color. When normal fish had patches put over their eyes, they did not change color when the backgrounds were changed. Without the patches they reacted to color changes in their surroundings.

Figure 3. Fish scales

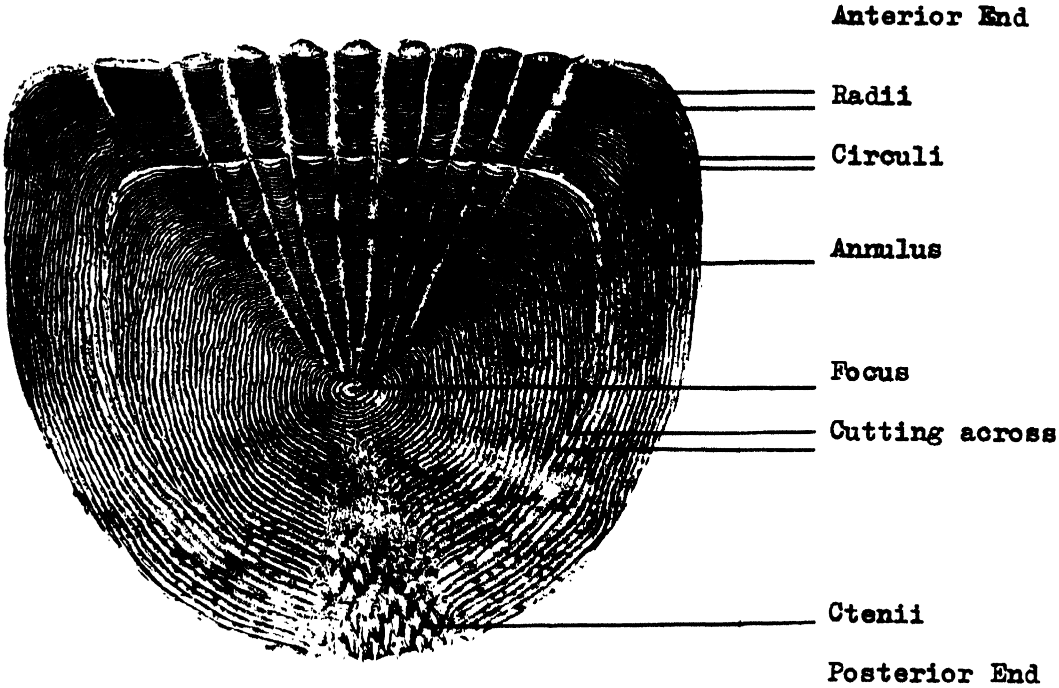


a. Placoid



b. Ganoid

Figure 4. Fish scales



c. Ctenoid

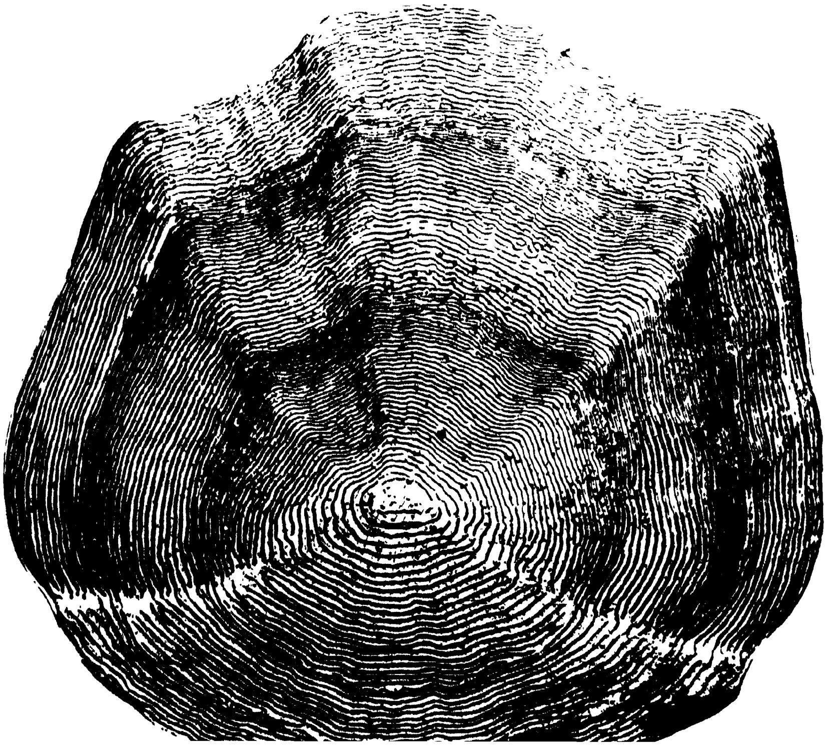
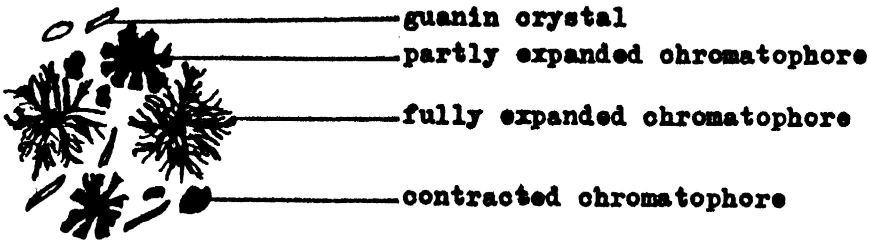


Figure 5. Color organs of fish



It is generally believed that color helps protect the fish from its enemies. Through varied color patterns and in being able to change color patterns with changes in their environment, the fish are better able to blend in with their surroundings, making it more difficult for the predatory fish to find their prey. During breeding season, when in many species the males, in particular, become brightly colored, there may be help given in recognition of mates or in selecting of mates.

The fins of the fish provide for the balance and motion. The fins may be divided into two groups — the paired and unpaired. The paired fins are the pectorals, representing the forelegs or arms, and the pelvic fins, representing the hind legs. The position of these paired fins varies with the species and is often used in identification as will be seen later.

The unpaired or vertical fins consist of the dorsal or back fin, the anal, and the caudal or tail fin. In some species there is an adipose or fat fin behind the dorsal. The dorsal fin may be divided sometimes into two or more parts, may or may not have enlarged bony rays or supporting rods. The fin, if it contains these stiff bony rays, is called the spiny dorsal fin, and the part containing the soft, non-spiny, branched rays is called the soft dorsal fin. Spines may be found in some species of fish on the other fins, except the adipose. All the fins generally aid the fish in balancing, but the caudal fin, with the body of the fish, is for propelling the fish. However, here again, some species use other fins to aid in motion. Some fish use their pelvic and pectoral fins to aid in crawling along the bottom of the lake or stream. Some, like the flying fish, use the pectoral fins to glide through the air. Some fish can even use their fins and climb trees, like the climbing perch.

In addition to the placement of the fins, the size and shape and the number of rays in the fins are of use in identifying the various species. This will also be further discussed in a later section.

The movement of the fish is accomplished by the muscles of the body. The muscles lie in sections, along the sides, forming the flesh of the body. They are not highly specialized muscles, as in the higher vertebrates, but there are several distinct sets. There are muscles for moving the jaws, gills, gill covers, eyes and the different fins, as well as the great lateral muscles which propel the fish. The lateral muscles are composed of many segments, usually zig-zag in shape. In buying canned tuna and other fish one can readily see these segments.

The skeleton of the fish is cartilaginous in the more primitive fish, and bony in the more highly specialized. The essential parts of the fish skeleton (Fig. 6) are the skull, backbone, and the two paired fins. The skull (Fig. 7) is composed of a great number of bones, and the shape and number vary with the species. The accompanying figure gives the names and the approximate location of most of the bones that are found in any skull.

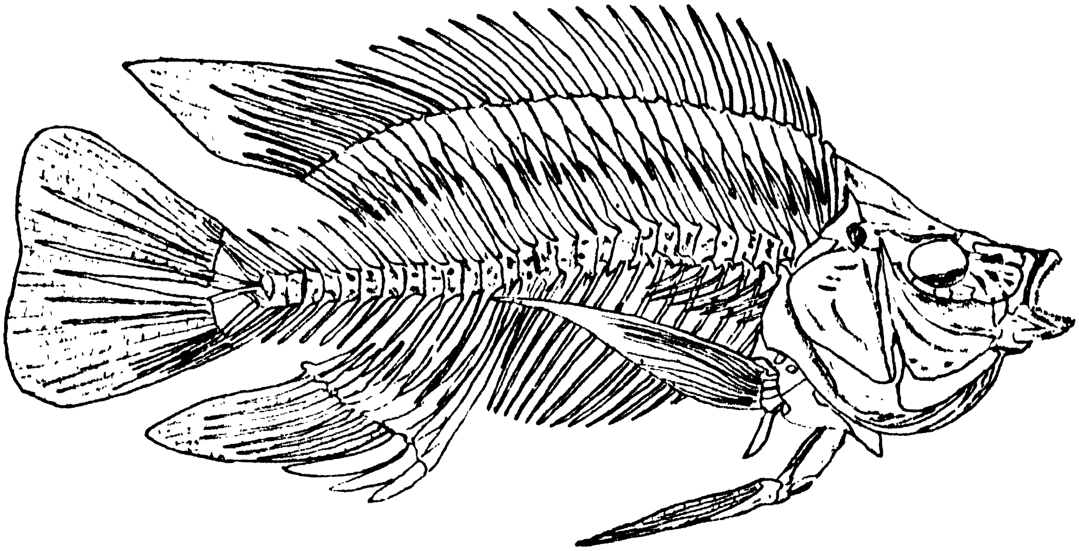
The backbone is composed of a number of vertebrae (Fig. 8), the shape of which depends on the location in the backbone. Generally two distinct forms are found. Those of the abdominal region and those of the caudal region. The abdominal vertebra has a round centerpiece or centrum, with the front and back faces distinctly concave, and a central hole. There are bony projections from the centrum, a dorsal one called the neural spine, which forms an arch through which runs the nerve cord; and the lateral ones from which the ribs project. Also attached to the centrum are some delicate intramuscular bones which extend into the muscles and can be most annoying in some fish when we eat them.

The caudal vertebra bears the neural spine and arch and a ventral spine and arch, called the haemal spine and arch. Through this arch runs the blood vessel carrying the blood to the tail section.

The posterior end of the caudal region is modified to form a supporting mechanism for the tail fin. The last centra may be turned up, down, or form a rod-like structure called the urostyle. The neural and haemal spines flatten out and become broad to form the base support of the tail. The shape the caudal section takes determines the style of tail the fish will have.

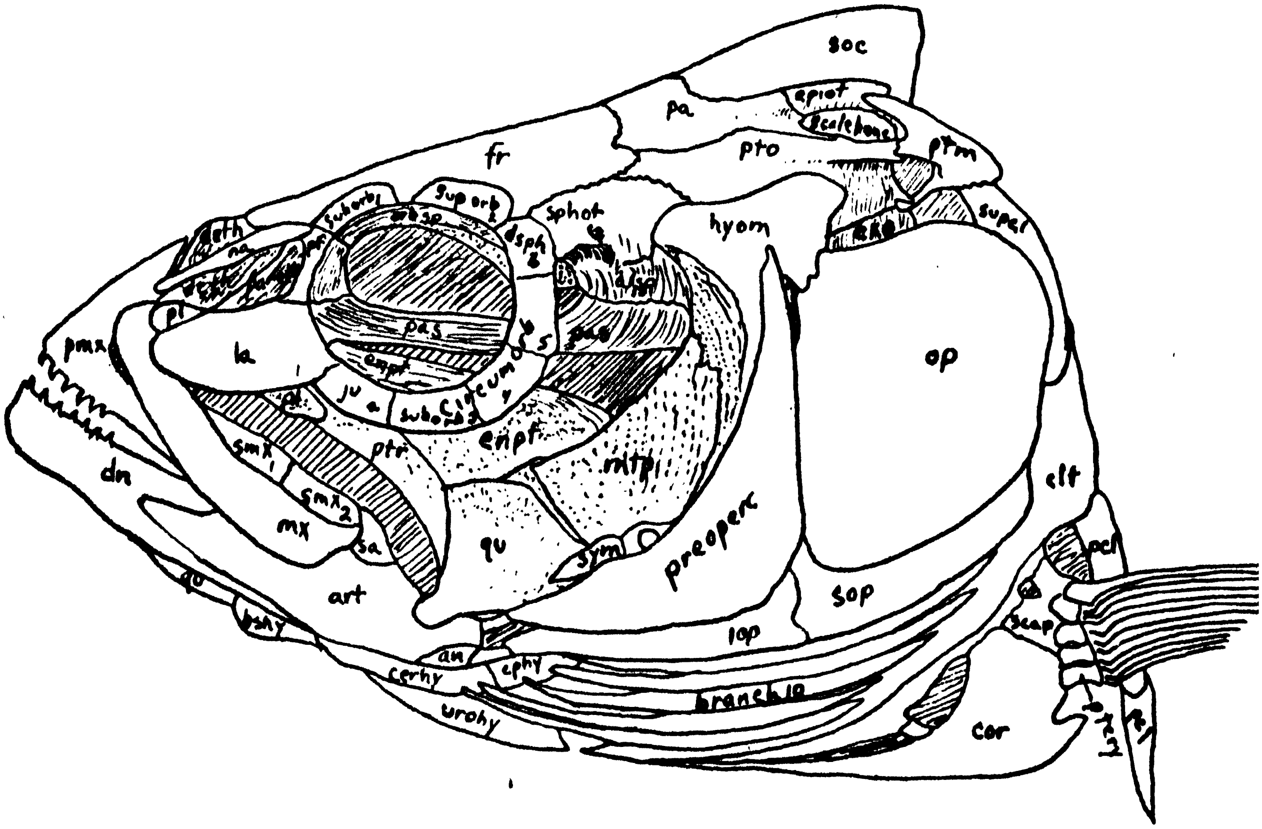
The shoulder girdle is attached to the skull and consists of several bones and ends in the fin rays. The pelvic girdle is usually composed of one large triangular bone and three small bones and ends in fin rays. In some species, the pelvic girdle is attached to the skull, in others to the shoulder girdle, and in still others it is attached only in the muscles of the abdominal wall.

Figure 6. Skeleton of fish (*Tilapia nilotica*)



(Redrawn from Bertin)

Figure 7. Generalized skull



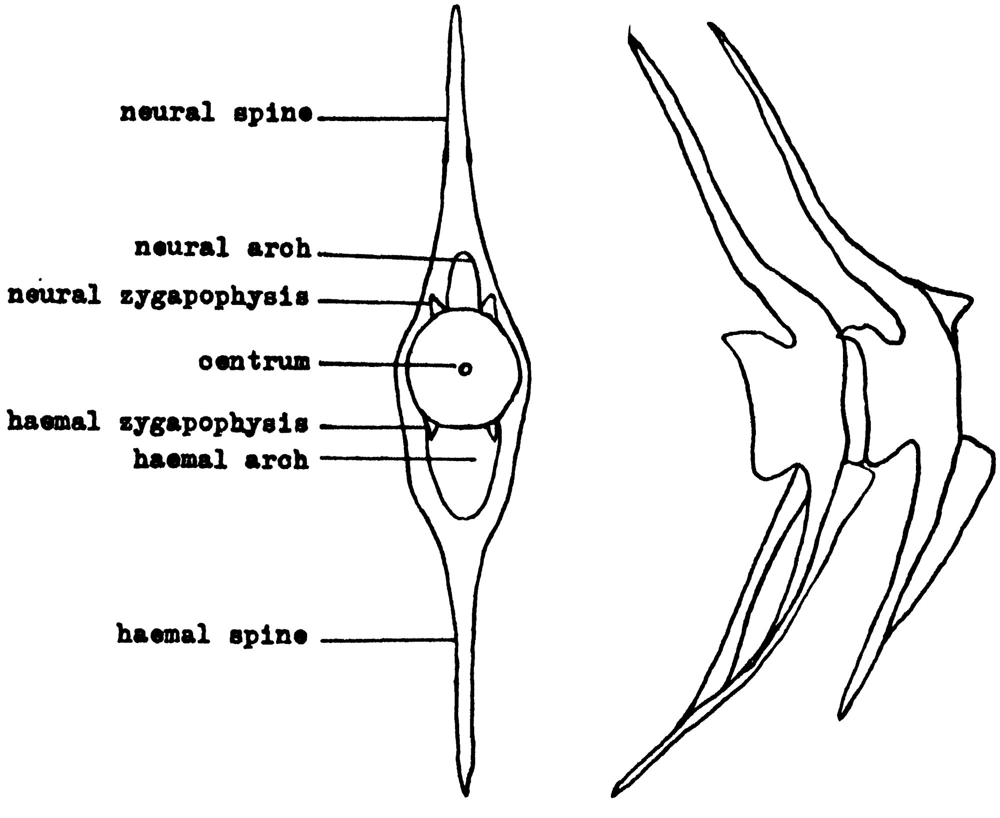
(After Gregory)

Key to Bones of Generalized Skull

deth — dermethmoid
na — nasal
pl — palatine
pmx — premaxillary
la — lacrymal
dn — dentary
ju — jugal or suborbital 2
smx 1, 2, — supramaxilla 1, 2
mx — maxilla
gu — median gular
bshy — basihyal
sa — surangular
art — articular
ptr — pterygoid
cerhy — ceratohyal
an — angular
qu — quadrate
urohy — urohyal
ephy — epihyal
enpt — entopterygoid
sym — symplectic
mtp — metapterygoid
branchio — branchiostegals
iop — interopercular
clt — cleithrum
sphot — sphenotic

sop — subopercular
preoperc — preopercular
cor — coracoid
op — opercle
scap — scapula
pcl — postcleithrum
supcl — supracleithrum
exo — exoccipital
ptm — post temporal
epiot — epiotic
pto — pterotic
soc — supraoccipital
pa — parietal
hyom — hyomandibular
alsp — alisphenotic
fr — frontal
dsph — dermosphenotic
circumorb — circumorbitals
suporb — supraorbitals
pas — parasphenoid
pf — prefrontal
pareth — parethmoid
suborb — suborbitals, 1 - 6
orbsp — orbitosphenoid
ptery — pterygium

Fig. 8. Vertebrae of fish (caudal)



The organs of nutrition (Fig. 9) are similar to those of the other vertebrates. A mouth, gullet, stomach, intestines and vent are to be found. Certain glands are also present, such as the liver, pancreas, spleen and kidneys.

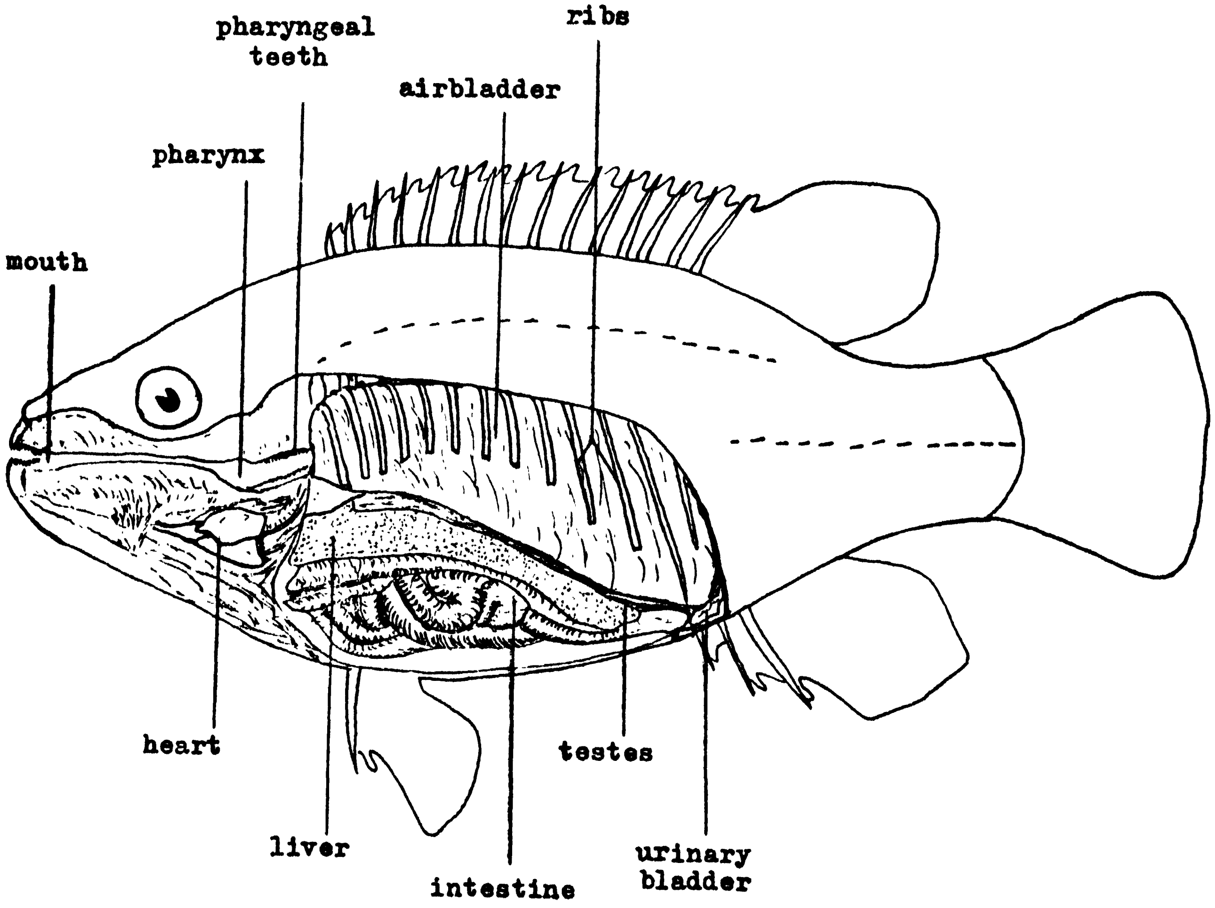
The mouth varies greatly in size and shape. In some fish, like the whale shark, the mouth may be a meter wide, while in others like the pipe fish the mouth is but a tiny hole at the end of a long beak. Mouths may be on the underside of the head or inferior, or at the end of the head or terminal, or on top of the head or superior. They may be adapted for biting or sucking. The type of mouth depends on the type of feeding done or may have been created by the type of feeding the fish engaged in. Some fish feed upon microscopic plants and animals that swim in the water and have mouths adapted to strain the water. In these specially adapted species, the gill rakers located opposite to the gill filaments on the gills, play an important part. The gill rakers act as strainers for the food. In other fishes, that feed on large items of food, the mouth may develop many teeth on the various bones which compose it. Some fishes have teeth in their throats and food is ground while passing through the gullet. Thus the mouth is a variable organ, and again can be used in identifying species.

Around the mouth may be developed sense organs in the form of barbels or whiskers. These aid the fish in finding its food. Some fish feed by sight, that is by seeing the object to be eaten. Others feed by smell, while still others may feed by feel, using the barbels as sense organs.

After the food passes through the gullet it may empty into a well-defined stomach, or in some fish merely an enlarged portion of the intestines. There are gastric juices provided by gastric glands which line the walls of the stomach, and these juices aid in the digestion of the food.

The intestine follows the stomach and is generally a simple tube. However, in some sharks it can develop into a highly complex organ with a spiral valve to increase the absorbing surface. The intestine's function is to absorb the food as in other vertebrates. The type of intestine often indicates the food habits of the fish -- a short straight tube generally indicates a carnivorous fish; a long coiled intestine an herbivorous fish; while a medium sized intestine suggests an omnivorous fish.

Figure 9. Organs of nutrition



Attached to the stomach or intestine in some species of fish are pyloric caecae. These pyloric caecae are small tubelike structures which appear to function as both digestive and absorptive organs.

The liver may be highly developed and bilobed, with a gall bladder, or it may be a simple undivided gland. The pancreas is usually developed as patches of tissue located around the intestine or imbedded in the liver. The spleen is usually attached to the stomach.

The kidneys lie along the inner side of the backbone with their ducts leading to the cloaca.

The last part of the intestine is called the rectum and it terminates in the vent. The vent may be a separate opening or it may end with the sex organs and urinary organs in a common opening called the cloaca.

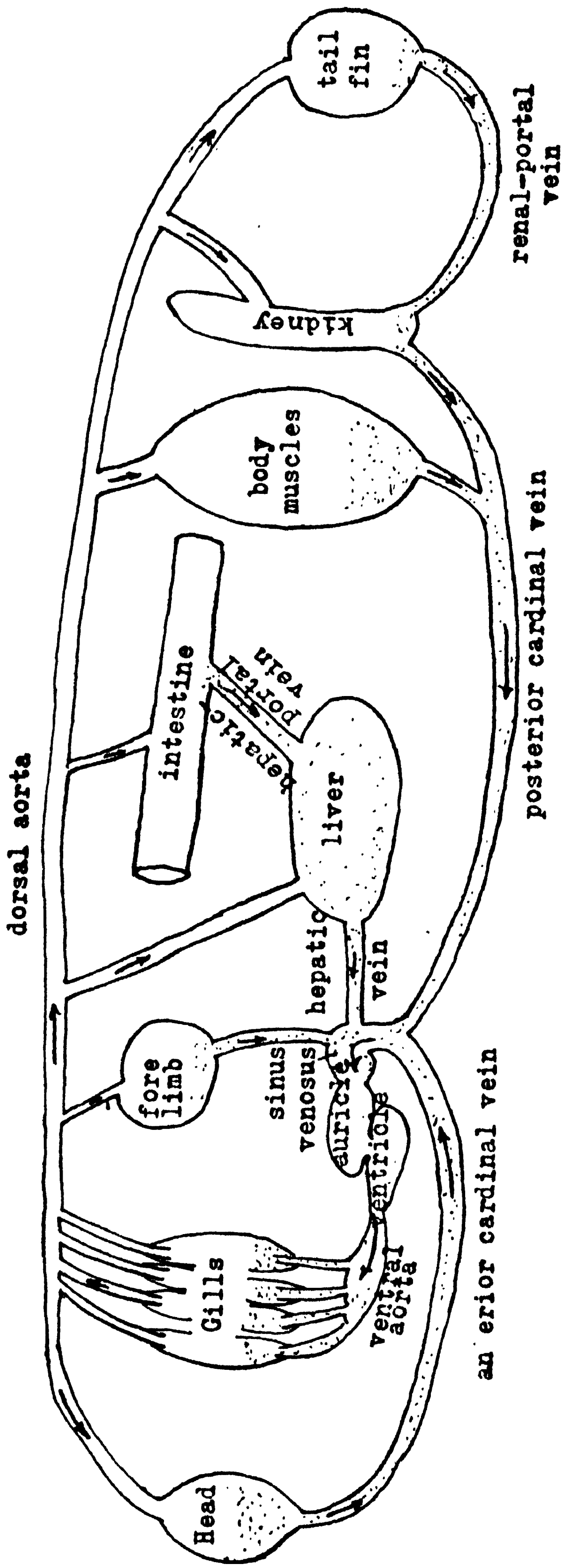
The circulatory system (Fig. 10) in fishes is quite simple. It consists of a heart, which is divided into three or four parts, and the arteries and veins which bring the blood to and from the various parts of the body.

The heart itself consists of an auricle or upper chamber, the ventricle or lower chamber, an enlarged area (in most fishes) before the auricle called the sinus venosus, and a thickened portion of the aorta or main artery leaving the heart known as the bulbous arteriosus. The wall of the sinus venosus is thin like that of the auricle, while the wall of the bulbous arteriosus is thick like the wall of the ventricle. The bulbous arteriosus aids the ventricle in pumping blood through the body.

The heart of the fish can be said to resemble the right half of the human heart, since it handles only venous blood. The ventricle forces the venous blood through the aorta which leads to the gills. In the gills the blood picks up oxygen and gives off the carbon dioxide and the oxygenated blood is then passed through the body through the various arteries. The used blood is collected in the veins and is then returned to the heart.

The blood is generally red in color and contains both red and white corpuscles. Blood circulation is slow and the temperature of the blood is a little above the temperature of the environment.

Figure 10. Circulatory system (schematic)



The heart is contained in a pericardial chamber and is located in the anterior part of the body cavity.

Respiration or breathing occurs in the water. Oxygen is removed from the water passing over the gill filaments and the waste gas, carbon dioxide, is given off in the same process.

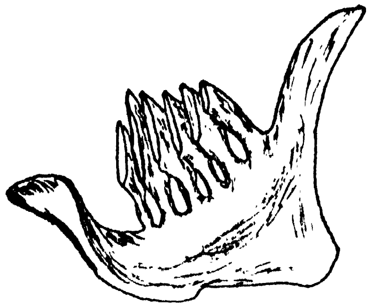
There are usually five pairs of bony arches attached to the cranium on top and to the base of the tongue below. Four of these pairs of arches bear gills, while the fifth usually does not. The fifth arch (Fig. 11) in some fishes develops teeth and forms the structure known as the pharyngeal teeth or gullet jaws.

Each gill arch (Fig. 12) bears two rows of slender filaments, the gills. Blood flows in and out each filament and thus comes in close contact with the water, the walls of the filament and the blood vessels in the gills being very thin. On the inside of the arch there are protective projections of varying sizes according to the species, called gill rakers. These gill rakers protect the gill filaments from large injurious particles being passed over them, and in some species are adapted to aid in the collecting of food, serving as strainers for the food particles which enter with the water.

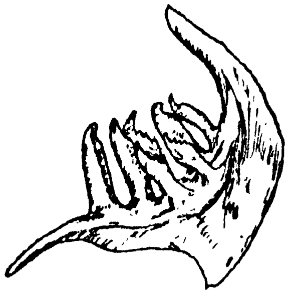
Water for breathing purposes is taken in the mouth and then forced out over the gills, through the gill openings. To aid in keeping the water from going back through the mouth, there are oral valves or flaps on the upper and lower jaw in the front part of the mouth which unfold over the opening and keep the water from being forced out of the mouth during the process of forcing the water out through the gill opening.

Some species of fish have an air bladder. The function of the air bladder is two-fold. It aids in breathing and also acts as an organ of flotation. In some fishes there is a tube leading directly from the gullet into the air bladder, and air can be gulped from the surface of the water. In other fishes there is no tube leading into the bladder and any gas

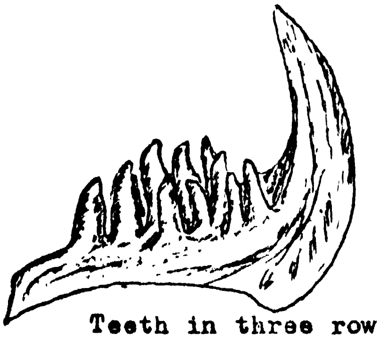
Figure 11. Pharyngeal teeth



Teeth in one row

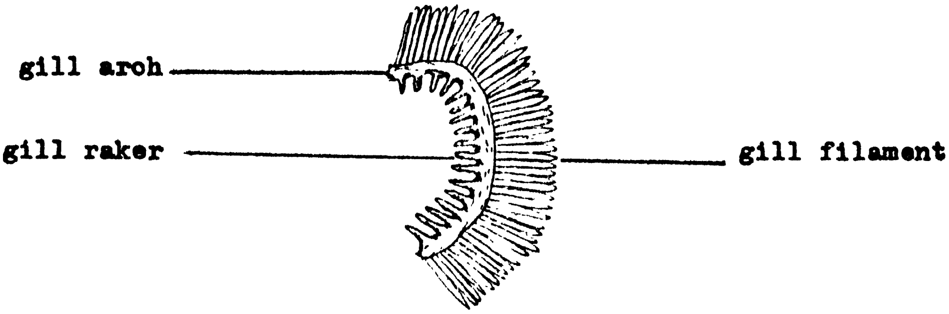


Teeth in two rows



Teeth in three rows

Figure 12. Gill arch



exchange takes place through blood vessels and a special organ on the air bladder. As an organ of flotation it helps the fish to float freely at given depths with little effort.

The organs of sense are generally the same as in other higher vertebrates. The sense of taste is quite weak, but there are taste buds present in the mouth and also in the skin. It is believed that fish react to four tastes -- sweet, sour, salty and bitter, though not all fish react to all four.

The sense of smell is located in the nasal or olfactory organs. These organs -- the nostrils -- have no connection with breathing in fishes as they do in higher vertebrates, since they are not usually connected to the mouth or throat. The nostrils in most species are deep pits lined with a delicate sensitive membrane which is well supplied with nerves and blood vessels. Water is drawn in and passed out of the nostril. As stimuli are received from food particles or odors, the stimuli excite the brain and the fish begins to search for the source of the stimulus.

The sense of touch is better developed. Barbels, or fleshy projections, have been developed in many species about the mouth, and are highly developed organs of touch. Touch cells are scattered throughout the whole skin of fishes as well as on these barbels.

The sense of pain is very feeble in fishes. Fish biting on a sharp hook and getting free will immediately turn back and bite the hook again. Injury, such as loss of an eye, does not seem to hurt the fish at all, and it gives no evidence of pain.

The ear in the fish consists of the internal ear only -- the vestibule and the three semicircular canals. There is no external ear, no ear drum, no eustacian tube. The ear serves two purposes -- hearing and in balance or equilibrium. The ear sac is located in the skull or at the base of the cranial cavity. This sac is divided into two parts -- an upper chamber or ultriculus and a lower chamber of sacculus. The semicircular canals connect to this ear sac and are filled with fluid.

The inner walls of the ear sac are lined with sensitive tissues and small bony ear stones or otoliths. An otolith in the sacculus part of the ear may develop into a large size and in some fish, like the cod, is used to tell the age of the fish, since as the fish grows the otolith grows and the depositing of lime about the stone forms rings which can be seen when the stone is ground down on a fine jewelers polishing stone.

The sense of hearing differs with the various fishes, but is generally weak. Nonetheless, fish do react to sounds carried by the water.

In some species, the air bladder is connected to the ear through a series of bones known as Weberian ossicles and is believed to aid in hearing or at least in amplifying the sounds.

Equilibrium or balance is closely associated with hearing and functions through the semicircular canals. In fish the equilibrium functions as for humans.

In some fishes, a sense organ called the lateral line system is developed. This is a canal or tube running down the side of the fish and puncturing each scale as it passes by. Nerves and sensory glands are found in and along the canal. It is believed this canal assists in several of the senses -- taste, touch and hearing. It is also believed it has a function in recognizing changes in heat and cold, and in detecting current changes.

The sense of sight is found in all fishes except a few species which have lost the power of sight by dwelling in underground waters as in caves, and in extreme depths of the oceans where light does not penetrate.

The eyes of fish vary in size and shape and location on the head. Some fish have even developed eyelids, but generally fish do not have eyelids. The major difference between the eye of the fish and those of higher vertebrates is the round crystalline lens of the fish eye rather than the elliptical lens of the higher animals.

Much has been written about the structure and details of the eye and sight, but for our purpose it is not necessary to go further into the structure.

Fish have eyes, they use them to see where they go, to obtain food and it has been shown that some fish can detect colors.

The nervous system in the fish consists of a brain and a spinal cord, with one set of nerves to bring stimuli to the brain, and another set to carry orders from the brain to the muscles, and a sympathetic system to control the workings of the organs. In fish the whole nervous system is very small and the gray matter is less developed than in higher forms.

In general the brain of a fish may be divided into three main parts — the forebrain, the midbrain and the hindbrain. The forebrain consists of two lobes, the olfactory or smell lobes. The size of these lobes depends on the type of fish. If it is a smell feeder these lobes are well developed, but if it is a sight feeder, they are relatively small. These lobes receive the nerves from the nostrils.

The midbrain is primarily for sight. The optic lobes make up this part of the brain. Again the size varies with the species of fish, those depending most on sight for food having the larger lobes.

The hindbrain consists of three parts -- the cerebellum, medulla and hearing lobes. The cerebellum has to do with balance. The medulla regulates the heart beat and breathing and controls swimming motion. Hearing and taste centers are also located in the hind brain.

The brain of the fish never completely fills the brain cavity. There is always a space between the brain and the bone which is lined with tissue and the space filled with a fatty fluid.

The spinal cord runs from the brain to the end of the vertebral column. The nerves of the fish are similar to those in higher animals both in location and function, but are fewer in number.

The reproductive organs in fishes are of two kinds, ovaries in the female and testes in the males. Eggs are developed in the ovaries which usually run the length of the abdominal cavity. The ovary is generally cylindrical and compact, yellowish in color and granular in appearance. In some species there is an oviduct or tube leading from the ovary to the genital pore or opening, while in other species the eggs are dropped into the body cavity and then are passed out through the pore.

The sperm are produced in testes which are usually two long, smooth, whitish organs. They usually extend the length of the abdominal cavity also, and each is connected by a duct, the sperm duct to the urogenital pore or sinus.

The ductless or endocrine glands play an important part in regulating the life of the fish as they do in the higher vertebrates. The pituitary gland is located on the ventral surface of the brain, as is the pineal gland. The thyroid gland is scattered patches of tissue in the region of the ventral sorts. Parathyroids are present in some fishes, absent in others. The thymus gland is above the branchial arches. Renal glands are located in the kidneys. The pancreas was mentioned in connection with the digestive tract.

Chapter II

Identification of Fishes

In the work to improve the fisheries of Syria, the first step is to find out just what kinds of fishes are present in the lakes and streams. From work already done here and in our neighboring countries we can expect to find about 86 different kinds of fishes. Some of these species are of value as food, while others are not. Some never grow to a size large enough for human consumption, but they may serve as food for other fishes which do grow to a large size.

In working with the fishes we must give them names so that we can collect information about them and put the proper information with the proper fish and be able to tell others about the work done. We cannot depend upon the names given them by the fishermen or the local residents, because the same fish may have several names in the different parts of the country, or several fish may have the same name. For example, Boori is a common name given to seven different species of fish by the fishermen. This problem is not only true for fishes, but for all plants and animals, and therefore a system of classification was derived so that any worker anywhere in the world would be able to determine and describe species of plants or animals so that everyone else would know just what plant or animal was meant. This system uses Latin or latinized names, because Latin is a language which no longer is subject to change in form or in meaning and interpretation,

First separation is made into the Plant Kingdom or the Animal Kingdom. Then each Kingdom is broken down into smaller and smaller units until one single species is left.

The animal kingdom is divided into a number of large groups, each known as Phylum. Each Phylum contains animals of similar anatomical likenesses, for instance the Phylum Protozoa contains only a single-celled animals. The Phylum Chordata contains all the animals with internal backbones. This Phylum is divided into a number of Classes, such as the Class Mammalia, Class Aves, or Class Pisces (or Fishes). .The Class Pisces is further divided into a number of Orders, which in turn are further divided into Families. The Families are subdivided into Genera and the Genera into Species. To the taxonomist, the man who is concerned only with the identification of animals, this grouping as given is a very simple one, and represents only the broad relationships. Each of the groups mentioned above is divided into subgroups by him for a better understanding of the relationships between animals. But for our purpose, the above is sufficient with the addition of one more smaller group. The species, in some few instances, is divided into a group known as subspecies. Minor variations occur which are not sufficient or consistent enough to warrant the complete division and the giving of a full species status, and these are given subspecies rank.

The system of classification is not finally settled and therefore is changing constantly as new information is obtained from new studies and the finding of new species. However, there are rules for the naming of animals, and these are followed by workers the world over. An International Commission on Zoological Nomenclature was formed and the rules agreed upon. With many workers working all over the world there is always some confusion and duplications arise. These problems are taken to the International Commission and settled by them.

The scientific name usually consists of two parts - the Genus and the species name. Occasionally, as mentioned above, a third or subspecific name is used. In writing these names the first letter of the Genus name is always capitalized, the species or subspecies name following is not capitalized. When printed in books or papers the names are put in italic type to distinguish them.

In the descriptions of the fishes that are to be found later in this book, it will also be noted that following the name of the fish is the name of the man who described the fish. It will be noted that sometimes the author's name is in parenthesis ( ). This means that since the man described the fish it has been placed in another genus by a more recent worker who has determined from further study that the fish belongs in a different group than originally believed.

Also in the animal kingdom, Family names always end in the letters IDAE. Above the family designation no one system of classification has yet been settled upon by all the workers for uniform endings of the various divisions, although several systems have been proposed.

To briefly summarise the classification system we will use in this work, will illustrate the system by tracing one fish through the kingdom.

Kingdom: Animalia
  Phylum: Chordata
    Class: Pisces
      Order: Eventognathi
        Family: Cyprinidae
          Genus: Barbus
            Species: kersin

Fish identification involves the use of many counts and measurements, recognition of parts of the body, and the location of the parts. To help correctly identify the fish captures, "Keys" to the families, genera, species, and subspecies have been constructed, and an explanation of the terms and measurements used in the keys and descriptions of the fish is given below. While at first the following pages may seem formidable, a little experience in the use of the keys will make the terms very familiar and little reference will have to be made back to these pages.

General Body Proportions

Total length of the fish (Fig. 1) is measured from the tip of the snout with the mouth closed to the tip of the tail with the lobes squeezed together. The measurement is a straight line and is not taken over the curve of the body.

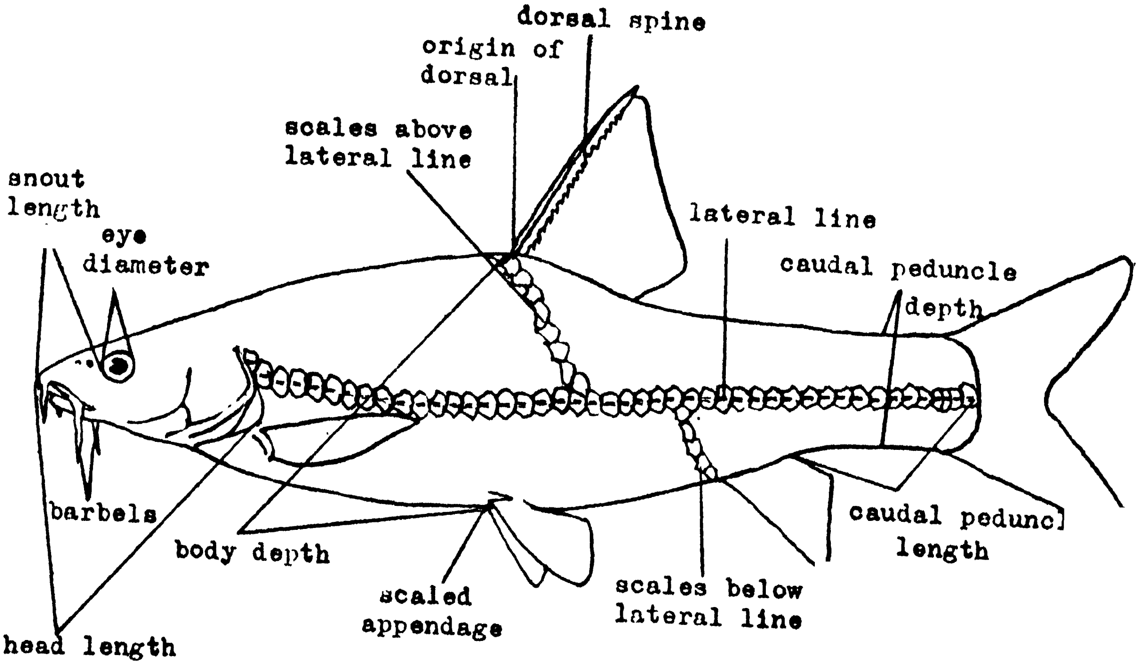
Standard length or Body length (Fig. 1) is measured from the tip of the snout with the mouth closed to the end of the backbone (to the structural base of the caudal fin rays).

Body depth (Fig. 13) is the vertical distance of the body at its deepest part. In the descriptions "Depth 4" means that the depth of the body is contained 4 times in the body length. Other terms such as slender, deep, etc., also are used. The following standards are used for such terms: very slender, 5.5 and above; slender, 4.0 to 5.4; moderately slender, 3.5 to 3.9; moderately deep, 3.0 to 3.4; deep, 2.5 to 2.9; and very deep, 2.4 and under.

Width of a fish is taken from side to side at the widest part of the body.

Caudal peduncle, or tail (Fig. 13) is the tapering portion of the body behind the base of the last ray of the anal fin.

Figure 13. General body proportions and measurements



Length of caudal peduncle (Fig. 13) is taken from the end of the base of the anal fin to the hidden base of the middle ray of the caudal fin.

Depth of the caudal peduncle (Fig. 13) is the smallest depth of that part.

Profile is the curve from the front of the dorsal fin to the tip of the snout.

Predorsal length is the distance from the front of the dorsal fin to the tip of the snout or upper lip.

The Head

Length of head (Fig. 13) is measured from the tip of the snout or upper lip to the most distant point of the operculum. (Some authors measure only to the end of the bone, others measure the soft membrane or "ear flap". Usually they will state the measurement used, but in comparing head lengths with those given in descriptions it is best to check both styles, if considerable disagreement is found with one measurement.) "Head 5" means the length of the head is contained 5 times in the body length. Standards for terms such as long, are as follows: long or large, 3.4 or less; moderate, 3.5 to 4.0; short or small, 4.1 and above.

Depth of head is measured from the midline at the occiput vertically downward to the bottom contour of the head or breast. If the cross line with the isthmus is distinctly away from this vertical, then the measurement is made from the occiput to the isthmus.

Occiput is the posterior dorsal part of the head.

Isthmus is the fleshy part between the gill openings, beneath the head.

Width of head is the greatest measurement when the opercles are in a reasonably normal position. (Sometimes the opercles are greatly distended when the fish dies. Then the opercles must be forced back to their normal position.)

Snout length (Fig. 13) is taken from the tip of the snout or upper lip to the front part of the orbit, squeezing the dividers slightly on the orbit if it has a fleshy rim in order to bring the dividers in contact with the hard bony rim. In this measurement, as in all others involving the snout, the start is on the midline.

Orbit is the cavity in the skull containing the eye.

Postorbital length of head is the greatest distance from the back of the orbit to the end of the membranous opercular margin.

Interorbital width is the horizontal distance between the eyes across the top of the head. (Sometimes the dividers are pressed tightly against the bony rims, measuring the least bony width, other times the dividers are not squeezed but measure the distance with the fleshy rim included, the least fleshy width. The measurement is usually specified.)

Length of orbit is the greatest distance between the orbital rims, and is often taken on the oblique.

Length of eye, or eye diameter (Fig. 13) is the measurement across the cornea, between the margins of the cartilaginous eyeball. "Eye 5" means the length of the eye is contained 5 times in the length of the head. Standards for common terms are: very large, 3.9 and less; large, 4.0 to 4.9; moderate, 5.0 to 6.9; small, 7.0 to 9.9; very small, 10 and above. These measurements are for adult specimens, young fish have relatively larger eyes.

Length of upper jaw, sometimes called maxillary length, is the distance from the tip of the upper jaw to the back end of the maxilla.

Gill rakers (Fig. 12) are slender rods or blunt knob-like projections from the anterior face of the gill arch. The count of the number of gill rakers is made above and below the angle or bend of the first arch, the upper number being mentioned first. The formula 6 / 13, for example, indicates 6 rakers on the upper arm, and 13 rakers on the lower. If the count is taken along the lower limb only, it is usually so stated. If a gill raker is at the angle of the arch, it is included in the lower arm count. All rudimentary rakers are included in the count unless otherwise stated.

Pharyngeal teeth (Fig. 11) are on the pharyngeal (throat) bones, located deep in the throat. They are modified fifth gill arches. They may be removed byy use of a needle with a hook in the end, a pair of fine tweezers or small knife. Care must be taken or the bone will break or the teeth will be broken off. A convenient way is to use the hooked needle, carefully inserting between the gill opening at the back of the opercular cavity and directly under the shoulder girdle, hooking onto the pharyngeal bone and gently pulling forward and outward. Caution also must be used in teasing the flesh away from the teeth so that they are not broken. With a little practice this removal and cleaning can readily be done.

Pharyngeal teeth counts (Fig. 11) give the number of teeth on the pharyngeal bones. In minnows and suckers the pharyngeal bone usually has 1 to 3 rows of teeth. The teeth in each row are counted and given in order from left to right. The formula 2, 4 - 4, 2 indicates that on the left side there are two teeth in the lesser or outer row, four teeth on the main or inner row, while on the right side there are four teeth on the inner and two teeth on the outer row. A " 4-4 " formula indicates only one main row with four teeth; while a " 1, 4-4, 0 " would indicate that the lesser row is represented on the left side, but not on the right.

Branchiostegal rays or Branchiostegals are bony rays supporting the membranes which close the gill cavity below the opercular bones. The number of these rays are frequently given.

The Fins

Dorsal fin or fins (Fig.1) are unpaired fins on the back. Spiny or spinous dorsal fin (Fig. 1) is the front portion of the double dorsal fin which consists of unbranched, non-joined spines.

Soft dorsal fin (Fig.1) is the back portion of the double dorsal fin which consists of soft rays which are usually flexible and branched. Occasionally the soft dorsal also will have spines.

Anal fin (Fig.1) is the unpaired fin on the lower side of the fish behind the anal opening.

Caudal fin (Fig.1) is the large unpaired fin at the posterior end of the body, the tail fin.

Pectoral fins (Fig.1) are the front paired fins attached to the pectoral arch.

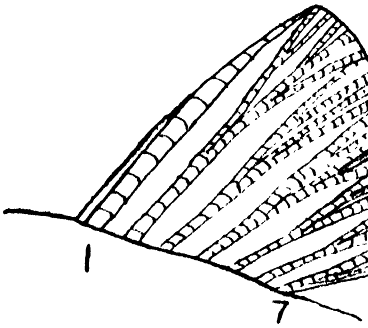
Pelvic fins (Fig. 1) are the posterior or lower paired fins attached to the pelvic girdle. They are considered abdominal (Fig.13) when they are nearer the anus than to the pectoral fins. They are considered thoracic (Fig.1) when they are nearer the pectoral fins than the anus.

Adipose fin is the small fleshy fin-like structure behind the dorsal fin, as in some catfish. This is sometimes more or less continuous with the caudal fin, being separated only by a slight notch, but most generally it is separate.

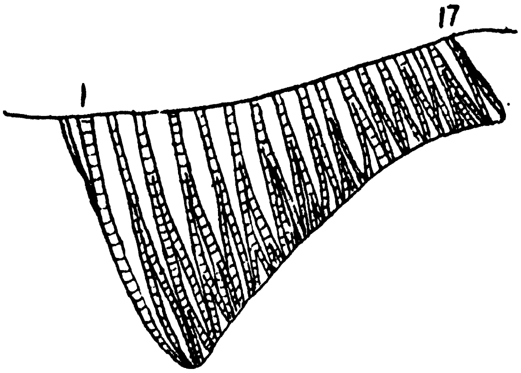
Fin ray counts (Fig.14). In counting the fin rays, rudimentary rays are omitted unless specifically mentioned. In descriptions Arabic numerals indicate the number of soft rays, and Roman numerals indicate the number of spines. If the fin is continuous and contains both spines and soft rays, a comma separates the numbers. "Dorsal fin X, 13" indicates a single fin with 10 spines and 13 soft rays. Two separate fins are indicated by a dash deparating the numerals. "Dorsal X - 12" indicates a single dorsal with 10 spines and 12 soft rays. "Dorsal X - I, 12" indicates a spinous dorsal fin with 10 spines, and a second fin with one spine and 12 soft rays.

Figure 14. Fin ray counts

a. dorsal fin



b. anal fin



Paired fin ray counts include all rays.

Rudimentary rays are those rays, generally at the beginning of the fin, which are unbranched, membraneless, closely joined to one another, and in ordinary cases not more than half the length of the fully developed rays.

Last ray of dorsal and anal fins (Fig. 14). The last ray of the dorsal and anal fins is split to the base appearing as two rays, although it is counted as one ray.

Height of dorsal and anal fins is taken from the origin of the fin to the tip of the anterior lobe.

Length of longest dorsal or anal ray is taken from the structural base of the ray to its tip.

Length of pectoral and pelvic fins. The length of the paired fins is the distance from the extreme base of the uppermost, outermost or anteriormost ray to the farthest tip of the fin.

Origin or Insertion (Fig. 13) of a fin are identical terms used for the place where the first ray or spine of the fin protrudes from the body. Generally origin is used for unpaired fins, and insertion is used for the paired fins.

Position of a fin is the distance from the tip of the snout to the base of the first ray or spine. For example, a fish description may give the position of the dorsal fin as contained twice in the fish's length.

Scale Counts

Lateral line scale count (Fig. 13) represents the number of scales in the lateral line, or if the lateral line is absent, the number of scales along a line in the position the line would normally occupy. The most anterior scale counted is the one touching the shoulder girdle. The count terminates at the structural base of the caudal fin (standard length point). Scales on the caudal fin base are not included.

Scales above the lateral line (Fig. 13) are counted from the origin of the dorsal fin, including small scales, downward and backward following the natural row to, but not including the lateral line scale.

Scales below the lateral line (Fig. 13) are counted upward and forward along a natural row from the origin of the anal fin to, but not including the lateral line scale.

Scale count designation. In descriptions, scale counts may be given as "5 or 6, 80-90, 7 or 8" which indicates the above described scale counts. The first figure "5 or 6" indicates the number of scales above the lateral line, the second series "80-90" indicates the lateral line count, and the third group "7 or 8" indicates the number of scales below the lateral line. Scales are frequently referred to as large, small, or moderate. Standards for these terms are: very large, under 40 in the lateral line; large, 41-60; moderate, 61-90; small, 91-150; and very small, 151 or more in the lateral line.

Cheek scales are counted as the number of rows of scales crossing an imaginary line from the eye to the preopercular angle.

Circumference scale count is frequently used in the Cyprinidae. It represents the number of scales crossing a line around the body in front of the dorsal fin at its origin.

Caudal peduncle scale count is taken similarly to the circumference count, but is made at the narrowest part of the caudal peduncle.

Other anatomical and technical terms used in fish descriptions

Air bladder. A sac filled with air or other gas, lying beneath the backbone. It may or may not be attached to the wall of the body cavity and may or may not be divided into compartments. It may or may not be connected by a duct to the esophagus. It may be absent in some fishes.

Anal. Pertaining to the anus or vent.

Anal papilla. A swelling or protuberance in front of the genital pore and behind the anus or vent.

Angular. A bony element in the lower jaw.

Anus. Posterior opening of the alimentary canal, the vent.

Apical radii. Grooves running from center of scale to its posterior face or exposed margin.

Articular. Bony element of the lower jaw.

Articulated. Jointed.

Axil. The angle between the pectoral fin base and the body.

Barbel. An elongated, membranous process attached to the mouth, chin or nose.

Basal radii. Grooves running from the center of the scale to the margin of the basal or covered portion of the scale.

Bony stay. A bony ridge extending from the eye region backwards across the cheek and ending in a spine on the opercle.

Branchial. Of the gills (branchiae).

Buccal. Pertaining to the mouth.

Caecal. Sac-like.

Caecum. A blind sac, or tubular diverticulum, connected with the alimentary canal. Plural Caecae. Example: Pyloric caecae.

Canines. Conical teeth in jaws which are larger than the rest.

Cardiform. Teeth which are coarse and sharp, like wool cards.

Carinate. Keeled, having a sharp median ridge.

Caudal. Pertaining to the tail or caudal fin.

Caudal spot. A pigment spot near the middle of the base of the caudal fin.

Cheek. Fleshy areas behind and below the eye and anterior to the opercle.

Chin. Anterior part of region bordered by mouth.

Chromatophore. A cell containing color pigment.

Circuli. Concentric ridges on the surface of the scales.

Compressed. Flattened from side to side.

Coracoid. One of the bones of the shoulder girdle, at base of the pectoral fin.

Cranium. Part of the skull enclosing the brain.

Ctenoid. Scales that bear minute spines or teeth on the exposed surface.

Cycloid. Scales that are rounded and which bear no teeth.

Dentary bone. Principal anterior bone of the lower jaw (Fig. 7).

Depressed. Flattened from above downwards, broader than deep.

Dorsal. Pertaining to the back.

Ectopterygoid. A paired bone of the roof of the mouth (Fig. 7).

Elongate. Comparatively long and drawn out.

Emarginate. Slightly forked or cut off along the margin.

Entopterygoid. A paired bone of the roof of the mouth behind the ectopterygoid (Fig. 7).

Entire. With margin complete, not forked.

Ethmoid. A bone of the skull in the region of the nose.

Falcate. Sickle-shaped; margin greatly concave.

Falciform. Sickle-shaped; falcate.

Filament. Any slender or thread-like structure.

Filamentous. Slender or threadlike.

Fontanelle. An opening between the bones of the skull.

Frenum. A bridge of tissues which binds or restrains; as the tissue which binds the upper jaw to the snout in some species.

Frontal bone. Bone forming front of skull.

Furcate. Forked.

Fusiform. Spindle-shaped.

Gibbose. Having a protuberance; convex; humpbacked, swollen.

Gills. Breathing organs in fishes. (Fig.12).

Gill arches. The bony supports of the gills (Fig.12).

Gill membranes. The thin wall of skin supported by the branchiostegals, and covering the gill opening from below.

Gonopodium. An intromittent organ, modified from the anal fin.

Graduated. Becoming progressively longer in one direction, said of spines of certain fishes.

Grinding surface. A flattened contact area of a tooth (Fig.11).

Haemal spine. The lower spine of a caudal vertebra (Fig. 8).

Humeral blotch. A conspicuous black area on the shoulder region of certain fishes.

Humeral spine. A spine on the shoulder, as on some catfish.

Hyaline. Transparent.

Hyoid. A bone in the floor of the mouth, a tongue bone.

Hyomandibular. One of the chain of bones forming the suspension of the lower jaw which connects it to the skull.

Hypercoracoid. A bone in the shoulder girdle, at base of pectoral fin.

Hypocoracoid. A bone in the shoulder girdle, at base of pectoral fin.

Hypural. The expanded last vertebra.

Imbricated. Overlapping.

Inarticulate. Not jointed.

Incised. Margin deeply notched.

Included. Refers to lower jaw position usually, lower jaw enclosed within upper jaw, not projecting.

Inferior. Lower.

Inferior mouth. Mouth decidedly on the underside of the head, opening downwards.

Infraorbital bones. A chain of small bones below the eye (Fig. 7).

Infraorbital canal. That portion of the lateral line system which passes behind and below the eye onto the snout.

Interneurals. The bones by which the rays of the dorsal fin are connected with the neural spines of the vertebrae.

Interorbital space. The space between the eyes.

Interopercle. A bone of the lower part of the side of the head. (Fig. 7).

Intromittent organ, or Gonopodium. A male reproductive organ developed in some live-bearing fishes from the modified anal fin.

Isthmus. The fleshy interspace between the gill opening.

Keeled. Having a sharp median ridge.

Lanceolate. Shaped like the long, narrow, tapering head of a spear.

Larva. The young of an animal, which must undergo a change of appearance before becoming an adult.

Lateral. To or towards the side.

Lateral band. A horizontal pigmented band along the side of a fish.

Lateral line. (Fig.13). A series of sensory organs, tubes or pores along the sides of the body of some fishes. The lateral line may be complete, even extending onto the caudal fin; incomplete, not reaching the caudal base; or entirely absent. The lateral line system may also extend onto the head where it divides into several branches. The lateral line is a structure and is not to be confused with color stripes of the lateral band.

Leptocephalus. Larva of the eel.

Lingual. Pertaining to the tongue.

Longitudinal. Running lengthwise.

Lunate. With a broad shallow notch.

Mandible. The lower jaw.

Maxilla or maxillary. Upper jaw (Fig.7).

Maxillary barbel. The barbel attached to the edge of the maxilla.

Melanophore. A black pigment cell.

Membrane bone. One formed within the skin, not a part of the original skeleton, as opercles in fish.

Mesocoracoid. A bone of the pectoral girdle.

Metapterygoid. One of the chain of bones connecting the lower jaw to the skull.

Molar. Teeth with a flattened, grinding surface.

Muzzle. The projecting part of the head including jaws, mouth and nose.

Myomere. A muscle segment.

Naked. Applied to fishes which lack scales on the body.

Nape. The back of the neck behind the occiput.

Nasal. Refers to nose.

Nasal bone. A bone on the roof of the nose.

Nostrils. Openings into the nasal chamber.

Neural spine. The uppermost spine of a vertebra.

Nuchal. Pertaining to the nape.

Nuptial tubercles. Outgrowths on head, body, and fins in the form of granules or tooth-like swellings that appear on some breeding fishes, especially males. Sometimes called pearl organs.

Oblique. Slanting or sloping.

Obsolete. All but disappeared; only faintly apparent.

Occipital. Refers to occiput or back of head.

Opercle. The posterior membrane bones on the side of the head; the principal bone of the operculum (Fig.7).

Operculum. Gill cover.

Opercular bones. The series of membrane bones on the sides of the head of a fish (Fig. 7).

Opercular flap. Prolongation of the upper posterior angle of the opercle.

Oral valves. Thin, membranous flaps used in breathing; just inside the mouth opening on the upper and lower jaws.

Osseous. Bony.

Oviparous. Egg laying.

Ovoviparous. Producing eggs which are hatched within the body before birth.

Ovum. Egg.

Palatine. A paired bone of the roof of the mouth, just back of the vomer, one on each side (Fig.7).

Palatine teeth. Teeth borne on the palatine bones.

Paired fins. The pectoral and pelvics.

Parietals. Roofing bones of the skull, above and just back of the eye.

Parr marks. Vertical dusky bars on the sides of the young of some fishes.

Pearl organs. Hard tubercles or granules developed on some breeding fishes, especially males; also called Nuptial Tubercles.

Pectinate. Having teeth like a comb.

Pectoral. Pertaining to the breast.

Pectoral arch. A bony framework usually connected to the skull and supporting the pectoral fins. The shoulder girdle.

Pelvic arch or girdle. The bony framework supporting the pelvic fins. The pubic bones.

Pendant. Hanging down.

Peritoneum. The membranous lining of the abdominal cavity.

Pharyngeal bones. Bones representing the 5th gill arch, behind the gills, near the entrance of the esophagus. As a rule they bear teeth.

Pigment. Coloring matter.

Plankton. Microscopic and semimicroscopic free floating plants and animals in the water.

Post-clavicle. A bone in the shoulder girdle.

Post frontal. A bone of the skull.

Post-temporal. The bone in the shoulder girdle connecting it to the skull.

Post-orbital. Bones of the orbital series, behind the eye (Fig. 7).

Precoracoid arch. Bony arch in front of the coracoid in soft-rayed fishes.

Prefrontal. Bone of the skull.

Premaxillaries. Paired bones forming the front of the upper jaw.

Preopercle. Membrane bone in the cheek.

Preorbital. Bone in front of the eye.

Prickles. Small spiny projections.

Protractile. Capable of being drawn forward.

Proximal. Nearest the axis of the body.

Pseudobranchia. Rudimentary gill-like structures on the inner, upper side of the operculum. Do not function as gills. Plural: Pseudobranchiae.

Pterygoids. Paired bones in roof of mouth, just back of palatines.

Punctate or punctulate. Dotted.

Pyloric Caeca. Finger-like appendages arising from junction of the stomach and intestines.

Quadrate. One of the chain of bones connecting lower jaw to the skull.

Radii. Grooves on fish scale radiating from center or focus to margins.

Ray. A supporting rod for a fin; two kinds, hard or spiny, and soft and flexible (Fig.14).

Rudimentary. Poorly developed.

Scute. A bony or horny plate.

Serrae. Structures resembling saw teeth.

Shoulder girdle. The pectoral arch which supports the pectoral fin.

Striate. Striped or streaked.

Sub-. A prefix to mean nearly, almost, in a lower position, below, beneath, under, slightly, moderately.

Subopercle. Bone below opercle (Fig. 7).

Suborbitals. Same as infraorbitals (Fig. 7).

Subterminal. Mouth so placed that upper jaw projects slightly over the lower.

Superolateral. Facing upward and outward.

Supplemental maxilla or supramaxilla. A bone lying on the upper posterior part of the maxilla, closely united to it (Fig. 7).

Supraoccipital. The unpaired bone at the back of the skull, usually with a crest above.

Supraoral. Above the mouth.

Symphysis. The point of union of the two parts of the lower jaw in front; the tip of the chin.

Symplectic. Bone joining the quadrate and the hyomandibular.

Swim bladder. Same as the air bladder.

Terete. Cylindrical or tapering.

Terminal barbel. At the end of the maxilla.

Terminal mouth. The mouth situated in a horizontal axis with body so that neither the upper or lower jaw projects.

Thoracic. Pertaining to the chest or thorax. Applied to pelvic fins when they are forward, close to the pectoral fins.

Transverse. Crosswise.

Truncate. Cut squarely off, as caudal fin in some fishes.

Typical. Of a structure the most usual in a given group.

Ultimate. Last or farthest.

Vent. Posterior opening of the alimentary canal, the anus.

Ventral. The lower surface. Occasionally the pelvic fins are called ventrals.

Ventral Profile. The ventral outline of a fish as seen from the side.

Vertebra. A single bone in the spinal column. Vertebrae- -more than one spinal bone.

Vertebral column. The series of vertebrae making up the backbone.

Vertical fins. The single fins — dorsal, anal and caudal — on the medial line of the body.

Villiform. Slender, crowded teeth forming velvety bands.

Villose. Covered with villi, or small slender projections.

Viviparous. Bring forth young alive.

Vomer. Bone of anterior roof of mouth, lying immediately behind premaxillaries; often bear teeth.

Weberian Ossicles or Apparatus. A chain of bones developed in connections with the modified anterior vertebrae and connecting the air bladder with the inner ear in catfish, carp and other minnows.

Use of the Keys

It is hoped that the keys which follow will enable one to identify any fish which may be caught in Syrian waters. It is to be remembered, however, that several of the species are very difficult to identify until considerable experience has been had in this work. Young specimens of many species are also very difficult to identify with certainty, and therefore as a beginning only adult specimens should be used. Later as one gains experience in this field, the identification of the young specimens may be undertaken. In the keys provided there has been no allowance made for hybrids between two species or genera. Hybrids do occur in nature and generally are recognized because their characters are intermediate between those of the parent species.

To find the name of the fish you have, the first step is to begin with item 1 a in the Key to the Families of Fishes of Syria. Throughout the series of keys prepared there are always two choices to be had — 1 a or 1 b, 2 or 2 b and so on until you find the correct identification of your fish.

Thus let us take an imaginary fish now and "run" it through the keys. First we turn to the Key to the Families of Fishes as mentioned above. We have two choices so let us assume our fish is in the group 1 b. It has a body that is not eel-like and has pelvic fins. Next, we go to item 3, either a or b. Determine whichever is correct. Let us again assume 3 b to be correct and then we must proceed to item 4 a or 4 b. Again decision is made. Assuming 4 b to be correct we proceed to 5 a or 5 b and compare our fish with these items. This time we will assume that our specimen has 2 dorsal fins (5 a) so we proceed to item 6 a or 6 b under this statement. Again our specimen has rays in the second dorsal so it belongs to the Family Mugilidae. We then turn to the page in the book indicated for the Family Mugilidae. Here we will find a description of the family followed by a Key to the Genera of Mugilidae. After checking the description to make sure the fish fits this description, we proceed to run it through the Genera key. Again we make the choices called for between the items as we did under the Family key. Assume again that our fish falls in item 1 b. This gives reference to the Genus Liza. Turn to the page with the description of the Genus Liza and again check the description. If the fish fits this description we proceed to the Key to the Species of the Genus Liza, and again make our choices as to how our specimens fits the items. When we have made our choice we will proceed to the detailed description of the species and check to see if our fish fits in all characters given. If it does, in all probability, we have properly identified our specimen. If it does not fit the description, we must begin again and check more closely on the individual items in the key.

KEY TO THE FAMILIES OF FRESHWATER FISHES OF SYRIA

1 a. Body eel-like; no pelvic fins
  2 a. Back with a series of short spines....................................MASTACEMBELIDAE, page 156
  2 b. Back without spines..........................ANGUILLIDAE, page 46
1 b. Body not eel-like; with pelvic fins
  3 a. Origin of pelvic in front of point of insertion of pectoral fins......................BLENNIDAE, page 51
  3 b. Origin of pelvic in back of point of insertion of pectoral fins
    4 a. Back with isolated spines.............GASTEROSTEIDAE, page 154
    4 b. Back without isolated spines
      5 a. Two dorsal fins
        6 a. Second dorsal with rays....................MUGILIDAE, page 159
        6 b. Second dorsal without rays (adipose)
          7 a. Conspicuous folds on chest...............SISORIDAE, page 178
          7 b. No conspicuous folds on chest......................................BAGRIDAE, page 48
      5 b. Single dorsal fin
        8 a. Dorsal fin far back, above or behind anal
          9 a. Dorsal fin with 9 or more rays.........................,.........CYPRINODONTIDAE, page 150
          9 b. Dorsal fin with 6 or 7 rays.......................................POECILIIDAE, page 169

8 b. Dorsal fin in front of anal
- 10 a. Body without scales...............SILURIDAE, page 172
- 10 b. Body with scales
  - 11.a. Mouth with 6-10 barbels........COBITIDAE, page 69
  - 11 b. Mouth with less than 5 barbels or none
    - 12 a. Anal fin with 3 or more spines..................CICHLIDAE, page 52
    - 12 b. Anal fin without spines, or with one spine.......................CYPRINIDAE, page 79

DESCRIPTIONS OF THE FISHES OF SYRIA

FAMILY ANGUILLIDAE

Body serpentine or eel-shaped, elongate and cylindrical, covered with fine scales which are deeply imbedded in the skin; head naked; lateral line present; skeleton osseous; vertebrae numerous, anterior ones not modified; pelvic fins absent;no spines on fins; dorsal and anal fins continuous with caudal; mesocoracoid absent; gill openings much restricted, about as wide as the base of the pectoral fins; operculum small, concealed beneath skin; mouth terminal, jaws about equal; premaxillaries absent; maxillaries lateral, separated on the medium line by the coalesced ethmoid and vomer; maxillary, mandible and vomer with cardiform teeth; air bladder with open duct. Young pass through a larval stage, a ribbon shape, known as a Leptocephalus.

One genus represents this family in Syria.

Genus Anguilla Shaw

Body elongate, compressed behind, covered with imbedded scales which are linear in form and placed obliquely, some of them at right angles to others; lateral line well developed; head long, conical, moderately pointed; teeth small, subequal, in bands on each jaw and a long patch on vomer; tongue tip free; lips full, with margin free behind, attached by frenum in front; lower jaw projecting; gill openings rather small, slit-like, about as wide as pectoral base and partly below pectoral; nostrils superior, well separated, the anterior with a slight tube; vent close in front of anal; dorsal origin at some distance from head, confluent with anal around tail; pectorals well developed.

A single species represents this genus in Syria.

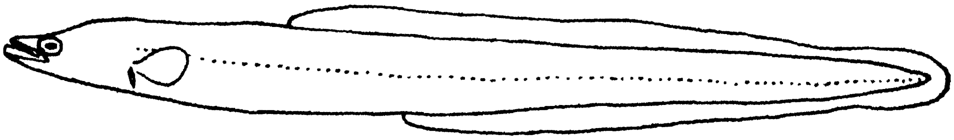
Anguilla anguilla (Linnaeus)

Head length contained 1 1/2 - 1 1/3 times in distance from gill opening to origin of dorsal; 2 1/3 to 2 2/3 in distance from gill opening to vent; distance of origin of dorsal in front of origin of anal as long as or longer than head; lips narrow; lower jaw prominent; angle of mouth below eye; eye small to moderate, shorter than snout; maxillary teeth equal and small; the tail is considerably longer than the body.

Color: brown, with lighter underneath, often tinged with yellow.

The life history of the Eel is a fascinating story, and only highlights will be given here. The eel lives in fresh water, in rivers and lakes. At

Figure 15. Anguilla anguilla



maturity, between 6 1/2 and 8 1/2 years, it undergoes a color change, becoming silvery on the belly and darker above. It migrates to the ocean and swims to an area between Bermuda and the West Indies. The eel spawns in the depths of the ocean, reportedly as deep as 300 meters. Spawning takes place in winter and early spring. The eggs hatch near the surface and the larvae, called Leptocephalus, drift with the Gulf Current. During this drifting period they grow to a length of about 3 inches. At this stage they change from the thin, flat, leaf-like form into a body form resembling the adult. These young eels are called Elvers. The elvers enter the rivers and streams where they grow up to lengths of 2 meters. The male generally stays near the river mouths while the female goes far upstream. It takes nearly 3 years for the larva to change into the elver, during which time it again crosses the Atlantic Ocean. The adults die after spawning.

The food of the larval eel is plankton. The food of the adult is almost anything. It is omnivorous, feeding on all forms of animal food, as well as plant materials.

This species may be taken in the rivers flowing into the Mediterranean Sea, especially the Orontes. Eels are good eating.

FAMILY BAGRIDAE

The rayed dorsal fin is always present, short, with not more than 12 soft rays, and belongs to the abdominal portion of the vertebral column, being placed in advance of the pelvics. The adipose fin is always present and well developed, although frequently short. The extent of the anal is much inferior to that of the caudal vertebral column. The gill membranes are not confluent with the skin of the isthmus, their posterior margin always remaining free, even if they are united with each other. Whenever the nasal barbel is present, it belongs to the posterior nostril. The anterior and posterior nostrils are remote from each other.

Genus Mystus Scopoli

Body moderately elongate and naked. Head depressed or compressed and ventrally flattened. Eye small, superior, with a free circular eyelid; placed above the angle of mouth thus not being visible from below ventral surface; orbital rim free. Nostrils small, in two pairs, set apart before the anterior end of orbit; a pair of barbels on the posterior pair. Mouth wide and transverse, cleft of mouth not extending halfway to orbit. Jaws sub-equal, upper jaw slightly longer; but in some species almost equal. Lips cutaneous and surrounding gape of mouth. Teeth numerous, villiform, in an uninterrupted semilunar band across the palate and on upper jaw; band on lower jaw interrupted in middle and deeply curved. Gill openings very wide extending forward for a considerable distance on the ventral surface. Gill membranes free, but overlapping each other and free from the isthmus. Upper surface of head plain or rough, with a median longitudinal groove. Occipital process of varying length and concealed by skin or slightly naked. Interneural shield may or may not be present.

Four pairs of barbels, one pair of maxillary barbels always longer than head, one pair of thin nasal barbels, two pairs of mandibular barbels, one inner pair always shorter than head, and other pair of varying length. Two dorsal fins, and anterior rayed dorsal with 7 rays and a serrated spine; a posterior soft adipose dorsal, free behind; rayed dorsal fin placed nearer tip of snout than base of caudal fin.

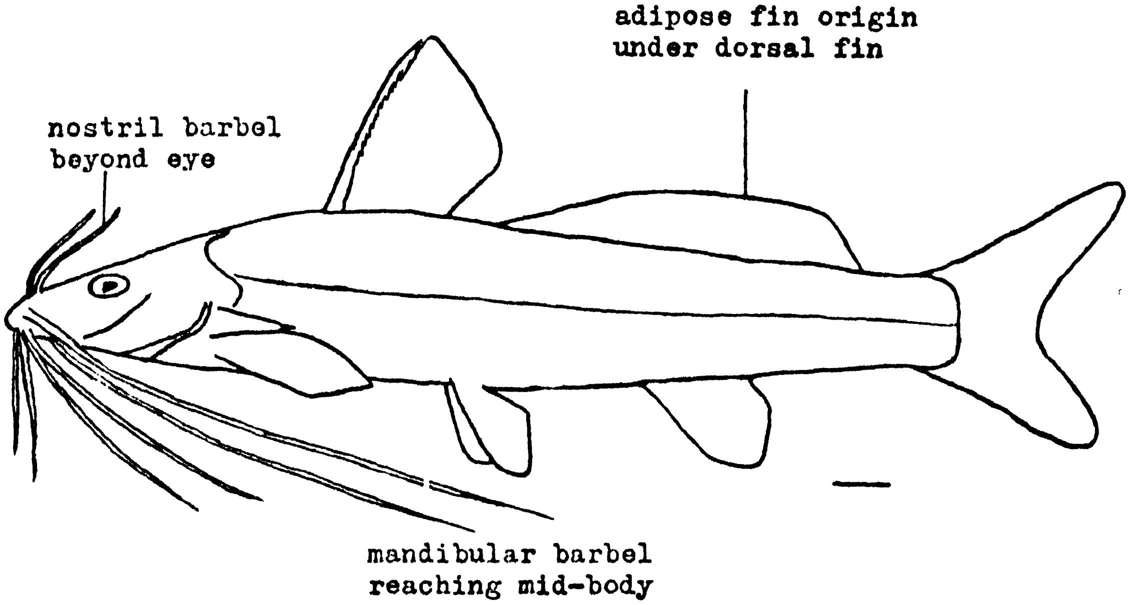
Pectoral fin with 8 - 10 rays and a pungent spine, stronger than dorsal spine. Pelvic fin with six rays not reaching base of anal fin. Paired fins almost horizontally inserted. Anal papilla may or may not be present. Anal fin with less than 15 rays, short, not reaching base of caudal fin. Caudal fin bilobed or forked, lobes being unequal and sometimes prolonged into filamentous extensions. Alimentary canal — stomach usually spacious with esophagus united at right side of stomach; intestines coiled.

Air bladder — of varying shapes, placed immediately below the alimentary, anteriorly connected, but posteriorly free. Internally a longitudinal complete or incomplete septum is present.

Mystus pelusius (Solander)

The height of the body is contained 5 1/3 times in standard length; length of head 4 1/2 times. Head rather broader than high; its greatest width being 3/5 of its length. Snout somewhat depressed, not very broad, its length 2/5 of that of the head; the upper jaw is longer. Nasal barbels small; those of the maxillaries extend to the origin of the adipose fin. Dorsal spine of

Figure 16. Mystus pelusius



moderate strength, scarcely serrated behind; as long as head without snout. Dorsal fin rounded above. The adipose fin commences immediately behind the dorsal and is nearly three times as long; it is lower than the hinder part of the tail. Caudal fin forked, with the lobes rounded, the upper being the longer. Pectoral spine as long as, but stronger than that of the dorsal fin, very strongly serrated. The pelvic fin is inserted below the end of the dorsal, and does not extend backwards to the origin of the anal. Dorsal rays I, 7; Anal rays 12; Pectoral rays I, 8; pelvic rays, 6.

Color: Grayish black above, with belly somewhat lighter.

At the present time nothing is known of its life history in Syrian waters. Specimens have been taken from the Orontes River, the Khabour River and are reported from the Kueik River.

FAMILY BLENNIDAE

Body elongate, low, more or less cylindrical, naked or covered with scales, which are generally small. The infra-orbital ring does not articulate with the preoperculum. One, two or three dorsal fins, occupying nearly the whole of the back; if a spinous dorsal is distinct it is as much or more developed than the soft portion; sometimes the whole dorsal is composed of spines. Anal fin long. Pelvic fins are jugular, composed of few rays, and sometimes are rudimentary or entirely absent. Air bladder generally absent; pyloric appendages are absent. Pseudobranchiae are present.

Genus Blennius Linnaeus

Body moderately elongate, naked; snout short; a single dorsal without detached portion; pelvics jugular, formed by a spine and 2 rays. Cleft of mouth narrow; a single series of immovable teeth in the jaws, generally a curved tooth behind this series in both jaws or in the lower. A tentacle above the orbit more or less developed, sometimes absent. Gill opening wide. Branchiostegals 6; pseudo-branchiae present; air bladder and pyloric appendages none.

One species represents this genus in Syria.

Blennius vulgaris Pollini

The height of the body is nearly equal to the length of the head, and 1/5 of the total length. The snout is slightly produced. A curved tooth on each side of the jaws. Orbital tentacle very small. The dorsal fin begins in the vertical from the extremity of the operculum, is very slightly notched, and is not continuous with the caudal. Dorsal rays XII, 18-20; Anal rays 18-20.

Color: Back brownish-olive; sides somewhat lighter; belly yellowish-white. Brownish spots, circular or oval, more or less accentuated on the back and sides. Sometimes two or three bands of brown on the cheeks.

This fish was taken in several coastal streams along the Mediterranean Sea.

The blennie is a small active fish that lives close to the stream bottom among the rocks and plants. They seldom grow larger than 15 centimeters. The blennie is one of the rare fishes of Syrian waters. Its food consists mainly of small bottom dwelling organisms. Because of its small size and scarcity, it is seldom used as a food fish.

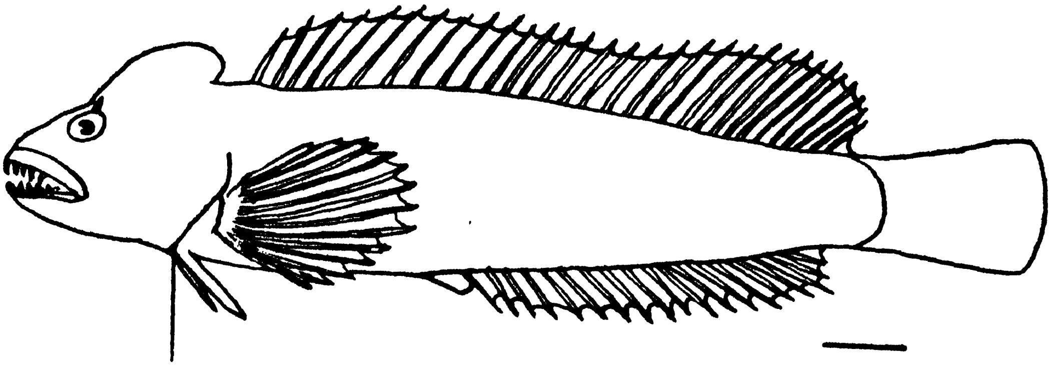
FAMILY CICHLIDAE

Body elevated, oblong or elongate, scaled, the scales generally being ctenoid. Lateral line interrupted or sub-interrupted. One dorsal fin, with a developed spinous portion; three or more anal spines; the soft anal similar to the soft dorsal. Pelvic fins thoracic, with one spine and five soft rays. Teeth in the jaws small; palate smooth. The lower pharyngeal bone triangular, with a median suture. Branchiostegals 5 or 6; gills 4; pseudobranchiae none; air bladder present. Pyloric appendages none (or in small number); stomach with a caecal appendage. The abdominal and caudal vertebrae are nearly equal in number, or the number of the former is slightly increased.

The species with lobate teeth and with many circumvolutions of the intestine are herbivorous, the others carnivorous.

The family is represented by three genera in Syrian waters.

Figure 17. Blennius vulgaris



KEY TO THE GENERA OF CICHLIDAE

1 a. Lower pharyngeal without blunt teeth.................TILAPIA
1 b. Lower pharyngeal with blunt teeth
  2 a. Lower pharyngeal with middle group of enlarged teeth..................................TRISTRAMELLA
  2 b. Lower pharyngeals with posterior group of enlarged blunt teeth......................HAPLOCHROMIS

Genus *Haplochromis* Hilgendorf

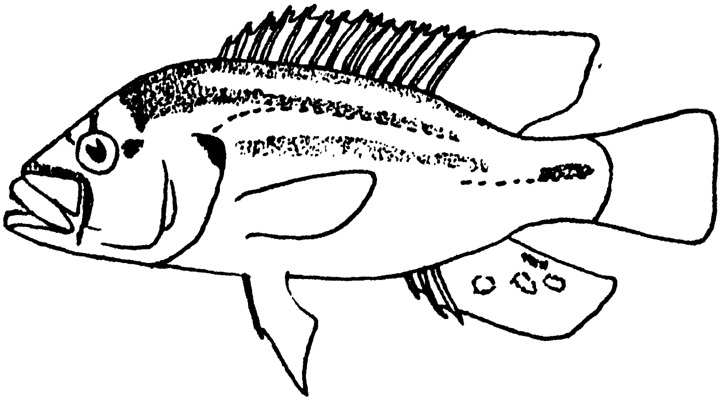
Body short or moderately elongate; scales ctenoid; two incomplete lateral lines. Teeth in 2 or more series, the outer conical or bicuspid, the inner usually tricuspid; maxillary bone exposed at the end when the mouth is closed. Dorsal fin with XIII - XIX spines; Anal with III-VI spines. 28-32 vertebrae.

This genus is represented by one species in Syria.

Haplochromis flavi-josephi (Lortet)

Depth of body 2.7 to 2.9 in length, length of head 2.6 to 2.7. Snout from as long as diameter of eye to 1.3 times as long, 3 to 4 times in head length. Diameter of eye 4 to 4.2 times in length of head, depth of preorbital 5.3 to 5.6; interorbital width 4.2 to 5; lower jaw length 2.5 to 2.7 in head. Maxillary extending to vertical from anterior edge of eye or beyond. Teeth in 3 series, outer unequally bicuspid or (in large males) conical, inner unequally tricuspid or conical; 38-44 in outer series of upper jaw. 7 gill rakers on lower part of anterior arch (excluding that at angle). 3 or 4 series of scales on the cheek. Lower pharyngeal bone larger in male than in female, with a posterior group of enlarged blunt teeth. 28-29 scales in longitudinal series, 5 or 6 from origin of dorsal to lateral line, 4 to 6 between pectoral and pelvic fins. Dorsal fin XIV, 9-10; Anal III, 8-9. Caudal fin subtruncate. Caudal peduncle a little longer than deep.

Figure 18. Haplochromis flavi-josephi



Color: Generally dark olivaceous. Traces of three dark bands one along middle of body, one along upper lateral line, and one at base of dorsal fin. In male, 1 to 3 bright ocellated spots anal fin.

This fish was taken in the springs of Muzerib and will also be found in Lake Tiberias and the waters connected with it.

Little is known of its life history.

Genus Tilapia A. Smith

Body compressed, oblong, covered with scales of moderate size; opercles scaly. Dorsal spines numerous, anal spines three. Teeth compressed, more or less lobate, in one series, behind which are other series of immature teeth. Anterior prominences of the branchial arches short, thin, lamelliform, non-serrated. Dorsal fin not scaly. Intestines with numerous circumvolutions.

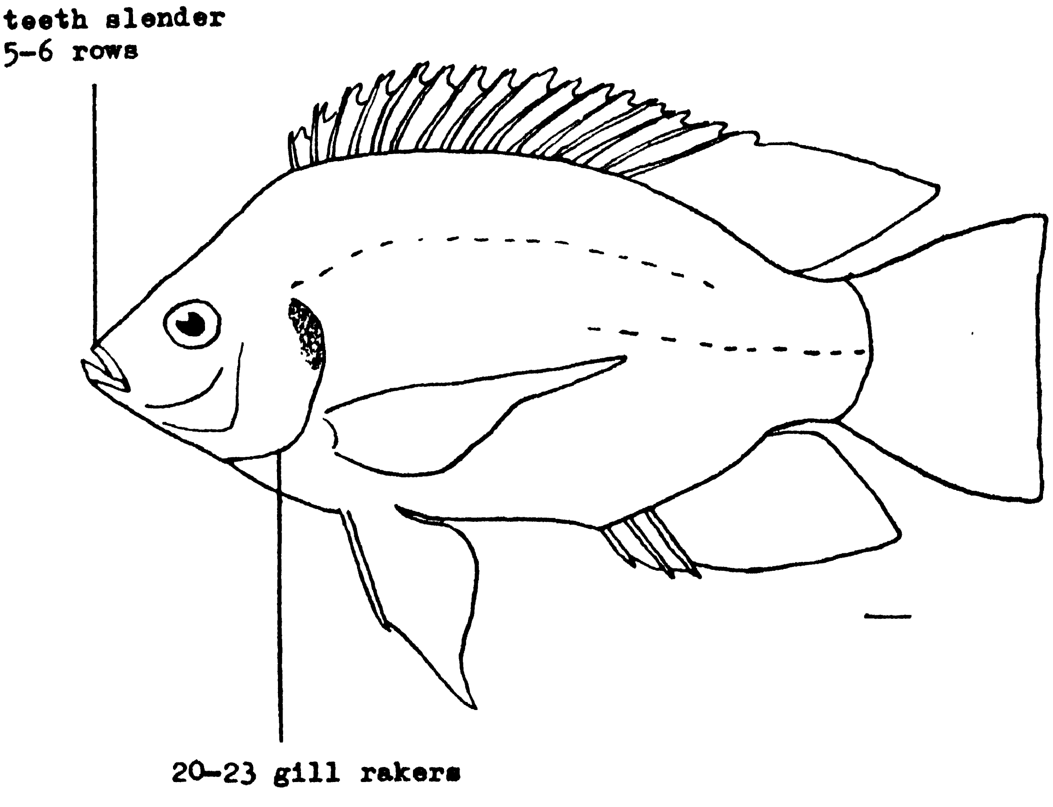
KEY TO THE SPECIES OF TILAPIA

1 a. Gill rakers less than 12 on lower part of anterior arch...... *T. zilli*
1 b. Gill rakers more than 13 on lower part of anterior arch
  2 a. Teeth in upper jaw, small, stout, in three or four rows; lower jaw with 3 to 5 rows of teeth; lower pharyngeal with toothed area more nearly triangular than heart-shaped, bearing numerous slender teeth which are neither so small or as densely packed as in *T. galilaea* .... *T. nilotica*
  2 b. Teeth in upper jaw very slender in 5 or 6 rows; lower jaw with 5 to 7 rows of teeth; lower pharyngeal with toothed area heart-shaped, with broad rounded lateral lobes, bearing densely crowded slender teeth.. *T. galilaea*

Tilapia galilaea (Artedi)

Depth of body 2 to 2.3 in length, length of head 2.7 to 3. Length of snout 2.9 to 3.4 in head, 1.2 to 1.6 times diameter of eye. Diameter of eye 4 to 4.8 times in length of head; depth of preorbital bone 3.5 to 4.3; length

Figure 19. Tilapia galilaea



of lower jaw 3.3 to 3.5, interorbital width 2.3 to 2.7. Teeth very slender, in 5 or 6 rows in upper jaw, 5 to 7 rows in lower, outer bicuspid, inner tricuspid, 92 to 100 in outer series of upper jaw (fewer in small specimens) Scales of cheek in two series below eye, sometimes three in front. Preoperculum at angle often wider than scaled part of cheek. 20-23 gill-rakers on lower part of anterior arch. Dentigerous area of lower pharyngeal heart shaped, with broad rounded lateral lobes, bearing a dense felting of slender, crowded teeth. 31 scales in a longitudinal series, 4 1/2 to 5 from origin of dorsal to lateral line, 5 to7 between bases of pectoral and pelvic fins Dorsal XVI, 13-14; spines strong, last contained 2 to 2 1/4 times in length of head. Anal III, 10-11; third spine stouter and a little shorter than last dorsal. Pectoral fin 1 1/4 to 1 1/3 times as long as head. Caudal peduncle 2/3 to 3/4 times as long as deep, its length contained 2.6 to 3 times in length of head. Caudal fin slightly emarginate in young.

Color: Generally dark olive, sides of abdomen silverish, with abdomen whitish. No dark bands on vertical fins.

This fish was found in Lake Tiberias and its connecting waters.

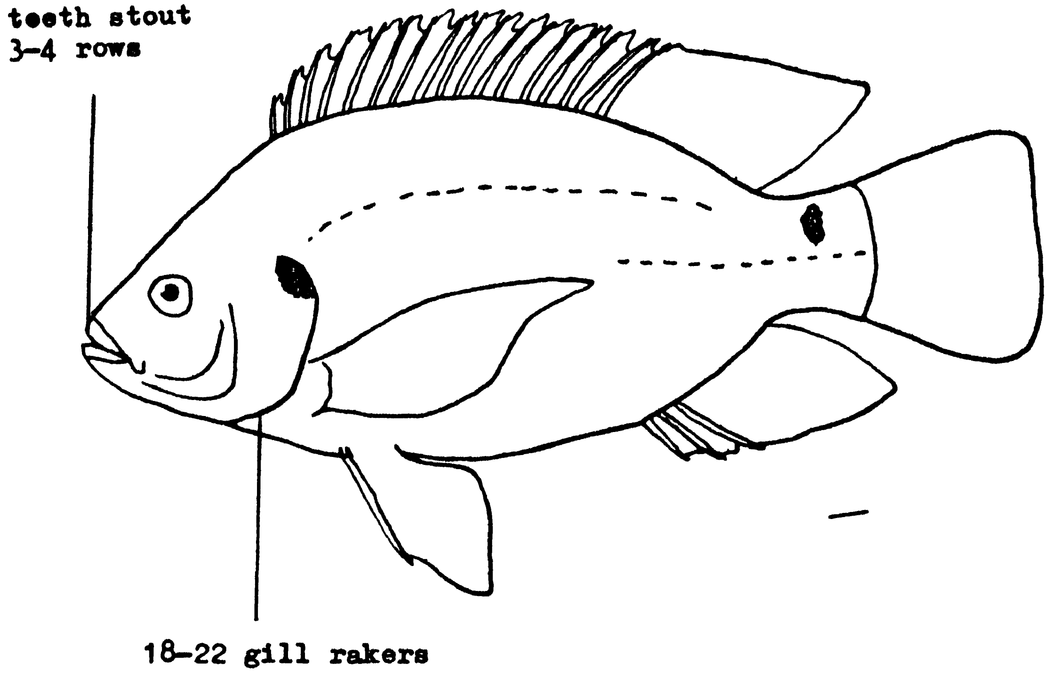
This fish is commonly called Musht abyad. It breeds by laying the eggs on the lake bottom during the spawning act and fertilization occurs at this time. Following this the eggs are picked up by either the male or female and are incubated in the mouth. After the fry hatch, they will return to the parent's mouth in times of danger. After about 10 days to two weeks the fry are able to take care of themselves, and quite frequently the adults will raise another brood of fish. Spawning occurs during April to August.

The food of the Musht abyad is plankton. They have been reported to have reached a length of 35 centimeters and a weight of nearly 1 kilo; the average size, however, is nearer 20 centimeters and a weight of 200 grams.

Tilapia nilotica (Linnaeus)

Depth of body contained 2.2 to 2.5 times in standard length, length of head 3 to 3 1/2 times. Snout 3.4 to 3.7 in length of head, 1.2 to 1.4 times diameter of eye, which is 4.4 to 4.7 in length of head. Depth

Figure 20. Tilapia nilotica



of preorbital 4.6 to 5 in length of head, interorbital width 2.5 to 2.8, length of lower jaw 3 to 3.2. Cheek with 2 or 3 series of scales. Teeth small, but stouter than in T. galilaea, in 3 or 4 series in upper jaw, 3 to 5 in lower, outer bicuspid, inner tricuspid, 70 to 80 in outer series of upper jaw. Gill rakers on the lower part of the arch 18 to 22. Lower pharyngeal with dentigerous area more nearly triangular than heart-shaped, bearing numerous slender teeth which are neither so small nor so densely packed as in T. galilaea. Scales 31 to 33 in a longitudinal series, 4 1/2 to 5 from origin of dorsal to lateral line. Dorsal XV-XVI, 12-13; length of last spine contained from a little more than twice to 2.3 times in length of head. Anal III, 10-11; third spine a little shorter than last dorsal. Pectoral a little longer than head. Caudal peduncle 3/4 as long as deep. Caudal truncate.

Color: Greenish-olive, shining silvery, each scale with a darker center; a dark spot on the operculum; the soft portions of the vertical fins with whitish spots, surrounded by oblique or transverse blackish streaks.

This species is also found in Lake Tiberias and its connecting waters.

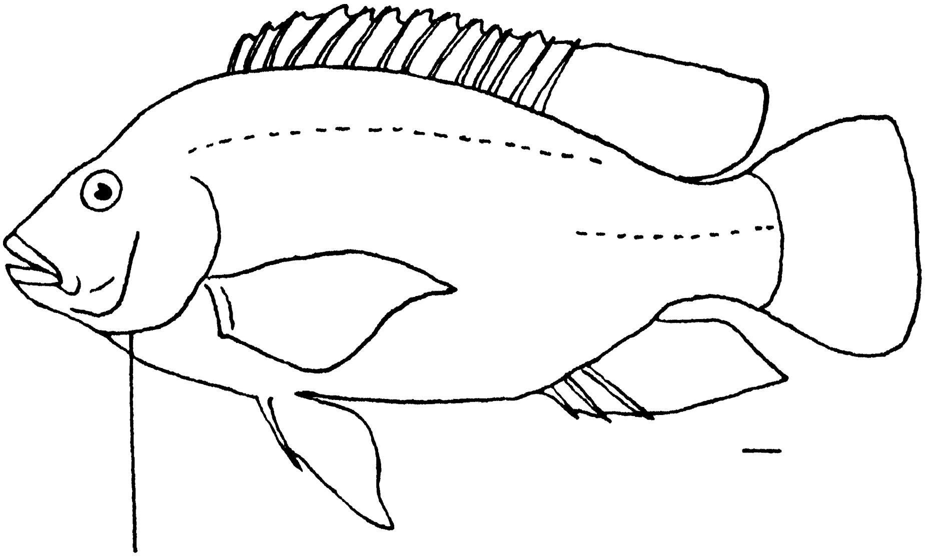
This fish is commonly called Musht lubud, and it may reach a length of 50 centimeters and a weight of 2,500 grams. This fish like T. galilaea is a mouth breeder. The eggs after being laid and fertilized are picked up either by the male or the female and are carried around in the mouth until they are hatched. Following hatching, the small fry will also return to the parent's mouth when they are frightened or are approached by other fish. Spawning occurs April through June.

The food of T. nilotica composed of phytoplankton, zooplankton, and insect larvae.

Tilapia zilli Gervais

Body depth 2 1/6 to 2 2/3 times in total length, length of head 2 2/3 to 3 1/3 times. Head 1 2/3 to 2 times as long as broad; snout with straight or slightly concave upper profile, a little broader than long, as long as or a little shorter than postorbital part of head; eye 3 1/3 (young) to 5 times in length of head, 1 (young) to 2 times in interorbital width, less than preorbital depth in adult; mouth usually rather large, 3/5 to 4/5 width of head, extending to below anterior border of eye, or to between nostril and eye. Teeth in 3 to 6 more or less regular series, outer largest, 20 (young)

Figure 21. Tilapia zilli



to 60 (adult) in upper jaw, and separated from the others by a rather wide interspace; 3 or 4 series of scales on the cheeks, width of scaly part equal to or greater than diameter or eye in adult. Gill rakers short, 8 - 11 on lower part of anterior arch. Dorsal XIV-XVI, 10 - 13; last spine longest, 2/5 to 3/5 length of head; middle soft rays more or less produced in adult, usually as long as head. Anal III, 7 - 10 (usually 8 or 9), third spine usually shorter than longest dorsal. Pectoral as long as head, or a little shorter, rarely slightly longer, rarely extending to vertical of origin of anal. Pelvic usually reaching vent or anal. Caudal truncate or rounded, subtruncate, rounded in old specimens. Caudal peduncle as long as deep, or a little deeper than long. Scales cycloid or very feebly denticulate, 28 - 33 in longitudinal series; 3 1/2 above, 11-15 below lateral line; lateral lines 17-22, 11-15.

T. zilli is easily distinguished from other species of *Tilapia* by the fewer gill rakers, 8 or 9 on lower part of arch, the deeper cheek and the almost horizontal mouth, and from all other Cichlidae of this region by the lower pharyngeal, which has a very short anterior blade and a broad triangular dentigerous area bearing relatively few and larger compressed, tricuspid teeth.

Color: Dark green, olive or brown, usually with 6 to 8 more or less distinct dark crossbars, with or without a dark stripe along the middle of the side; a black opercular spot; sometimes a dark vertical bar below eye; vertical fins with dark markings, which often form oblique streaks on the dorsal and anal fins, and may form a network on the caudal fin; a black spot on the base of the anterior soft dorsal rays; caudal fin often dark, with or without round whitish spots; in life, lower parts often dark blood red.

This species is also found in Lake Tiberias and its connecting waters. Its common name is Musht addadi. It grows to a length of about 30 centimeters and a weight of about 800 grams.

The eggs are laid in nests built in the bottom muds and are guarded by the adults. In this species the young are not taken into the mouth when they are frightened. The spawning season is longer than for *T. nilotica* and extends from March to July.

Genus *Tristramella* Trewavas

Articular surface for upper pharyngeals formed by the parasphenoid only; inferior apophyses for support of the anterior end of the air bladder on fourth vertebra; lower pharyngeal bone with a middle group of enlarged teeth. Vertebrae 29 (14 - 15).

Key to the Species of *Tristramella*

1 a. Head 2.5 times in standard length;
teeth in jaws conical.................................*T. sacra*

1 b. Head more than 2.5 times in standard
length (2.6-3); outer teeth in jaws bicuspid

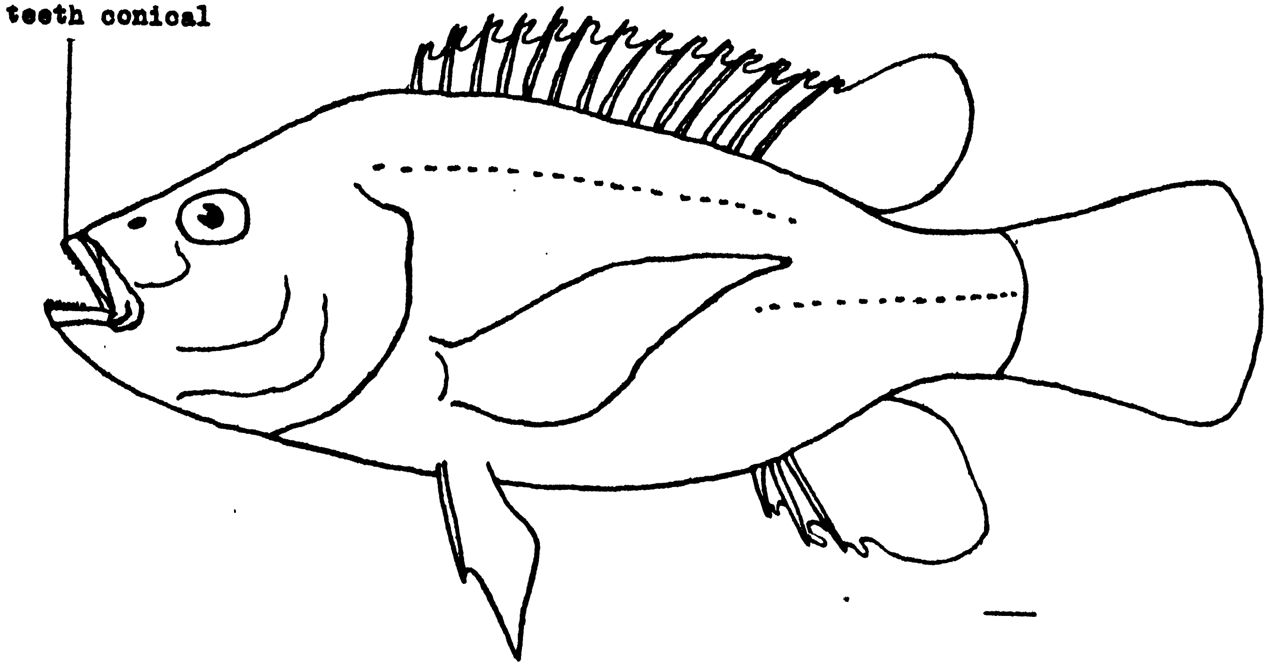
  2 a. Depth of body 2.5 - 2.6 in length;
  eye diameter contained 4.5 -5 in
  head length....................................*T. simonis simonis*

  2 b. Depth of body 2.3 in length; eye
  diameter contained 5 to 5.7 in
  head length...............................*T. simonis magdalenae*

Tristramella sacra (Gunther)

Depth of body 2.5 to 2.8 in length; length of head (excluding projecting part of lower jaw) 2.5, Snout 2.8 to 3 times in length of head, twice to 2.3 times diameter of eye. Diameter of eye 5.6 to 6.3 times in length of head, depth of preorbital 3.9 to 4.7, interorbital width 4.1 to 4.6, length of lower jaw 2.2 to 2.4, of premaxillary pedicels 3.7 to 4.1. Lower jaw projecting. Teeth conical, in 3 or 4 series anteriorly in upper jaw. 2 series laterally, 58 to 64 in outer series. 4 or 5 series of scales on the cheek. 10-11 gill rakers on lower part of anterior arch. Lower pharyngeal bone very slightly longer than wide, toothed part twice as long as anterior blade; teeth of four middle rows enlarged except posteriorly, lateral teeth slender, not densely crowded. 30-31 scales in a longitudinal series, 3 1/2 to 4 from origin of dorsal fin to lateral line, 5 to 7 between bases of pectoral and pelvic fins.

Figure 22. Tristramella sacra



Dorsal XIV, 10-11; last spine about 1/3 length of head. Anal III, 8-9; third spine a little shorter than last dorsal. Pectoral 5/6 to 6/7 as long as head, extending to origin of anal or beyond. Caudal rounded, subtruncate. Caudal peduncle a little longer than deep.

Color: Dark olive or brown.

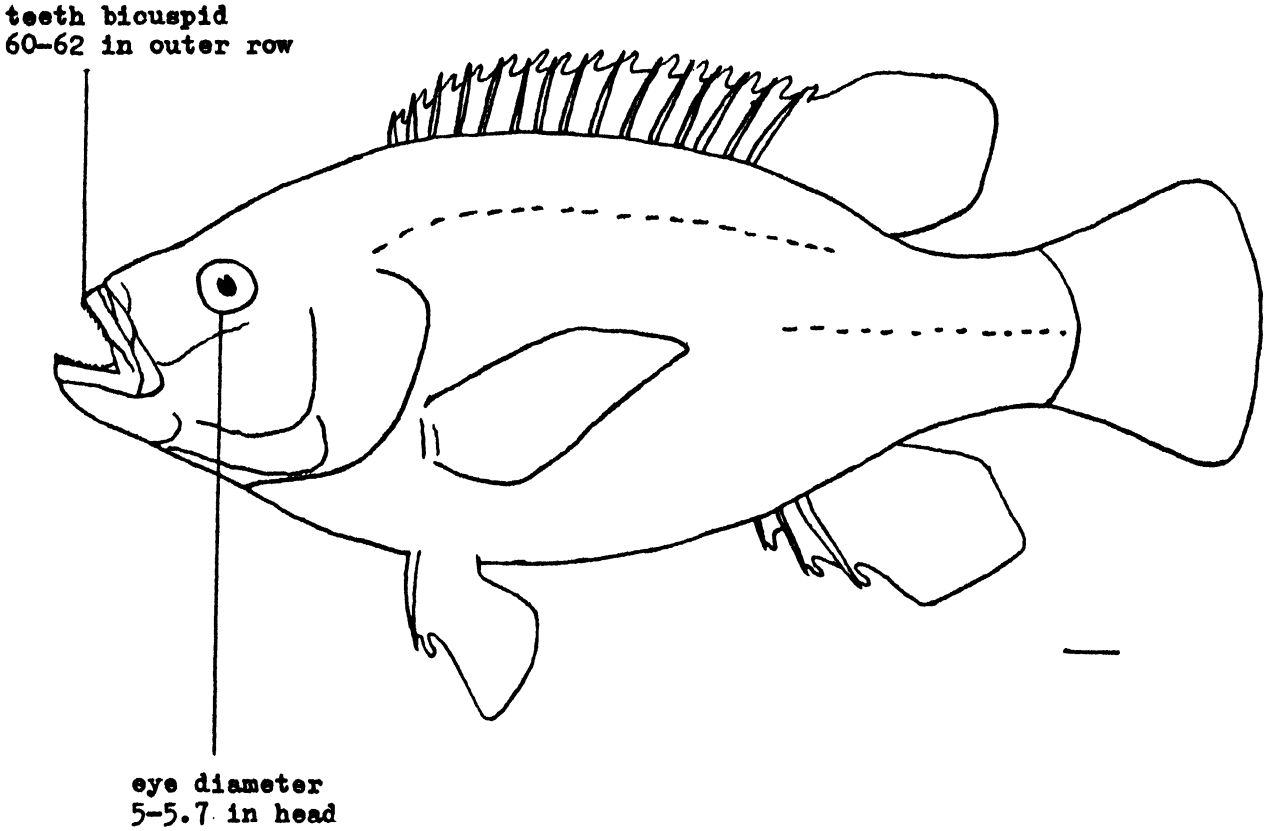
This species is also found in the region of Lake Tiberias. It, too, is a mouth breeder, spawning in the spring. It is reported to reach a length of 26 centimeters and a weight of 250 grams. Although its food is primarily zooplankton and insect larvae, it has been reported that it eats small fish also. Its common name is Musht kelb.

Tristramella simonis magdalenae (Lortet)

Depth of body 2.3 to 2.4 in the length; length of head 2.6 to nearly 3. Length of snout 3.3 to 3.6 in length of head, 1.4 to 1.75 times diameter of eye, which is contained 4.9 to 5.7 times in length of head. Depth of preorbital 4.3 to nearly 5 times in length of head, interorbital width 3.3, length of lower jaw 2.6, of premaxillary pedicels 3.5 to 3.9. Maxillary not, or just, reaching vertical from anterior edge of eye. Teeth in 3 or 4 series, outer bicuspid, inner tricuspid, 60 to 62 in outer series of upper jaw. 4 series of scales on cheek. 9 or 10 gill rakers on lower part of anterior arch. Lateral line pores of preoperculum and preorbital single, or at most two or three at opening of a bony canal. Lower pharyngeal bone a little wider than long, the length of its toothed area contained 1.5 or 1.6 times in its total length; lower pharyngeal teeth slender and crowded laterally, enlarged in 4 to 6 middle series, except posteriorly, some blunt. 30 to 31 scales in longitudinal series, 4 from origin of dorsal fin to lateral line, 7 or 8 between bases of pectoral and pelvic fins. Dorsal XIV-XV, 10-11; last spine 2.6 to 3 times in length of head. Anal III, 8-9 third spine shorter than last dorsal. Pectoral a little shorter than head, extending to above origin of anal, or nearly. Caudal rounded, subtruncate. Caudal peduncle as long as deep or a little shorter.

Color: Adult fish dark olive or brown, sides somewhat mottled but not strongly striped, belly lighter. Dark spot on opercle. Dorsal and anal

Figure 23. Tristramella simonis magdalenae



and caudal fins irregularly spotted with dark markings. Pelvic and pectoral fins with darkened rays. Young fish show 7 to 8 faint vertical bars and a black spot on soft dorsal which fades after fish attain 3 to 4 inches.

This fish is found in the waters in the vicinity of Damascus. It is a mouth breeder and follows the pattern described for the Tilapia. It spawns from April to August. It grows to a length of about 25 centimeters, though usually is smaller. It feeds on vegetation.

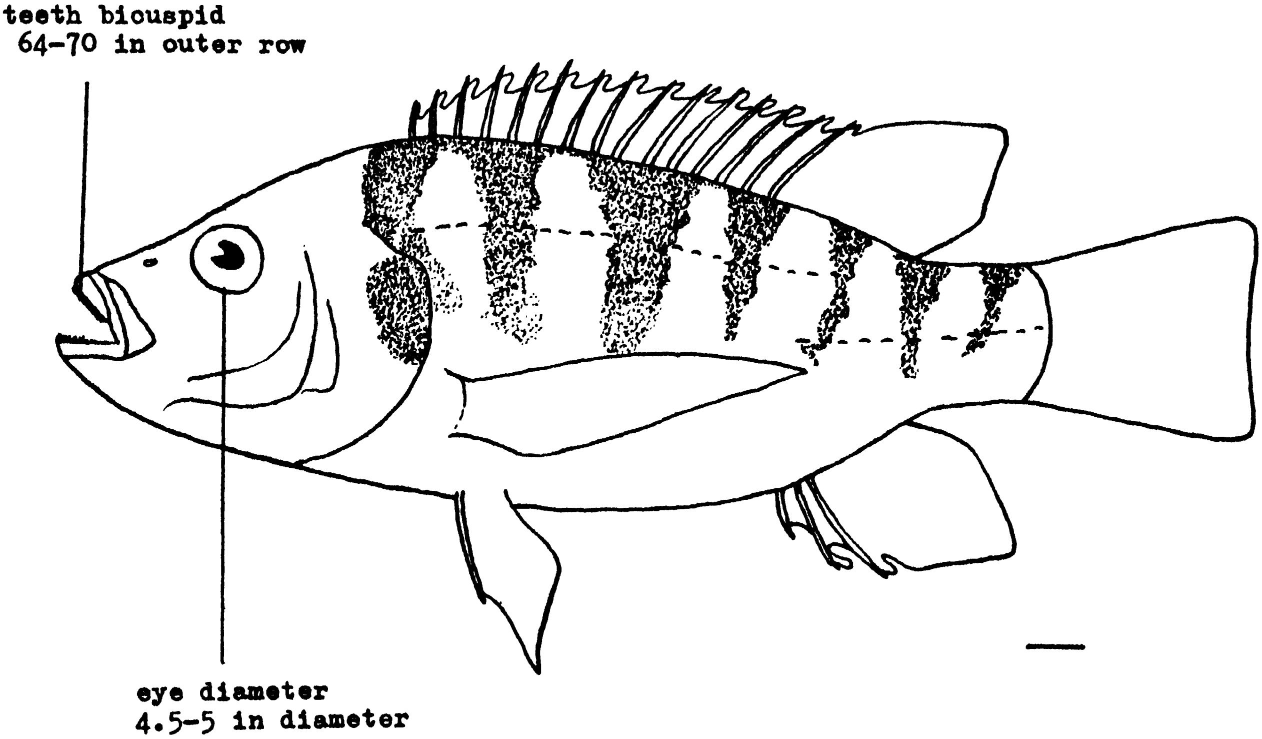
Tristramella simonis simonis (Gunther)

Depth of body 2.5 to 2.6 in the length, length of head 2.7 to 2.8. Length of snout 1 1/2 times diameter of eye, which is 4.5 to 5 in length of head. Depth of preorbital 4.5 to 4.8 in head, interorbital width 3.25, length of lower jaw 2.5 to 2.6, of premaxillary pedicels 4.2 to 4.3. Lower jaw slightly projecting; maxillary not extending to below eye. Teeth in 3 or 4 series, outer bicuspid, inner tricuspid, 64 to 70 in outer series of upper jaw. 3 or 4 series of scales on the cheek. 11 or 12 gill rakers on lower part of anterior arch. Lower pharyngeal a little longer than wide, 1.7 to 1.8 times as long as the median length of its toothed area; pharyngeal teeth small, pointed and rather numerous laterally, rather stout in the middle series. Lateral line pores on preoperculum and preorbital multiple, 5 to 10 at each opening of the bony canal. 31 scales in a longitudinal series, 4 from origin of dorsal to lateral line, 7 between pectoral and pelvic fins. Dorsal XV, 10; last spine 2.4 to 2.6 in length of head. Anal III, 9-10; third spine a little shorter than last dorsal. Pectoral as long as head, extending to above origin of anal, or beyond. Caudal rounded, subtruncate. Caudal peduncle as long as deep, or a little shorter.

Color: Body dark olive or brown, sides with quite definite vertical bars, a dark spot on operculum, belly lighter.

This species is also found in the Lake Tiberias region. It is known locally as Musht marmur. It, too, is a mouth breeder. It grows to a length of about 25 centimeters and a weight of 200 grams. It spawns from March to August. It is a vegetable feeder.

Figure 24. Tristramella simonis simonis



FAMILY COBITIDAE

Body rather long. Mouth surrounded by six or more barbels. Dorsal fin short or of moderate length; anal fin short. Scales small, rudimentary or entirely absent. Pharyngeal teeth in a single series, in moderate number. Air bladder partly or entirely enclosed in a bony capsule. No pseudobranchiae.

This family is represented by two genera in Syrian waters.

KEY TO THE GENERA OF COBITIDAE

1 a. Erectile, bifid suborbital spine below eye...Cobitis

1 b. No erectile, bifid suborbital spine below eye... Nemachilus

Genus Cobitis Linnaeus

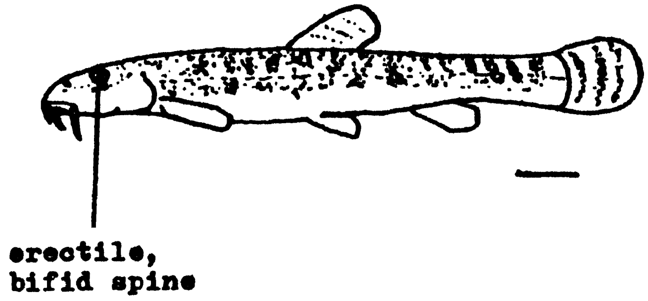
Body more or less compressed, elongate; back arched. A small erectile, bifid spine below the eye. Six barbels only on upper jaw. Dorsal fin inserted opposite to pelvics; caudal rounded or truncate. Air bladder enclosed in a bony capsule.

Cobitis taenia Linnaeus

Body much compressed; barbels very short; eye small, in middle of the length of the head. Scales inconspicuous. The origin of the dorsal fin is somewhat in advance of that of the pelvics.

Color: Body generally yellowish tan, back with median line of larger brown confluent spots, a lateral line of brown spots, sometimes confluent, and a small band of irregularly placed brown spots between the above two bands. Interspaces between bands finely specked with brown. Belly and lower sides plain. Caudal and dorsal fins with rows of brown dots. Head mottled with brown dots, generally a band from eye to end of snout.

Figure 25. Cobitis taenia



This species was taken in the Orontes River and is probably present in most of the rivers emptying into the Mediterranean Sea. It is usually found in the swifter flowing waters, over gravel bottoms. It spawns in April or May, laying its eggs which are adhesive on the bottom among the small rocks, or among the aquatic vegetation. It is a bottom feeder, a scavenger. It may reach a length of 12 to 15 centimeters.

Genus Nemachilus van Hasseltine

Body elongate and feebly compressed, naked or covered with minute scales. Mouth small, inferior, enclosed by the lips; three pairs of barbels; two on the snout and one on the side of the mouth. Suborbitals small, without spines. Gill slit reduced on the sides. Pharyngeal teeth small, pointed and more or less hooked, in a single row. Lateral line complete, median. Dorsal short, composed of 10-17 rays with three simple, opposite to the pelvics or just back of them. Anal short, formed of 7-9 rays, 3 simple. Air bladder entirely or partially enclosed in a bony capsule, open on the sides.

KEY TO THE SPECIES OF *NEMACHILUS*

- 1 a. Body mottled with black spots
  - 2 a. Snout produced, pointed, length more than postorbital portion of head .... *N. insignis*
  - 2 b. Snout short, obtuse, equal or shorter than postorbital portion of head
    - 3 a. Dorsal fin border convex, origin nearer base of caudal than tip of snout .... *N. panthera*
    - 3 b. Dorsal fin not convex, origin nearer tip of snout than base of caudal
      - 4 a. Dorsal fin margin concave, black band on snout... *N. frenata*
      - 4 b. Dorsal fin margin straight, no black band on snout .... *N. galilaeus*
- 1 b. Body barred
  - 5 a. 10-12 irregular crossbars, black band from eye to snout .... *N. argyrogramma*
  - 5 b. 15 or more crossbars; usually no black band on snout .... *N. tigris*

Nemachilus argyrogramma (Heckel)

The height of the body equals the length of the head and is contained 4 1/3 to 4 1/2 times in the length without the caudal. The head is 1 1/2 times as long as wide. The snout is obtuse. The eye is contained about 5 times in the length of the head, 2 times in the snout length, and 1 1/2 times in the interorbital space. The barbels of the snout have the inner pair equal to the eye and the outer pair a little longer; the barbel at the angle of the mouth is about 1 1/2 times the eye diameter. The dorsal origin is a little nearer the snout than the origin of the caudal; its longest rays measure about 3/5 the length of the head; its superior border is straight or slightly rounded. The anal,

Figure 26. Nemachilus argyrogramma

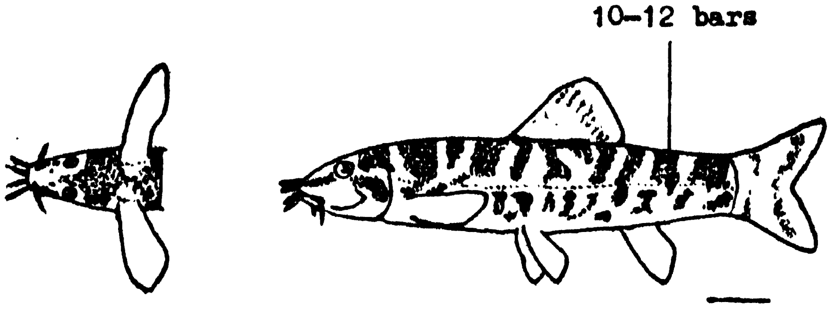
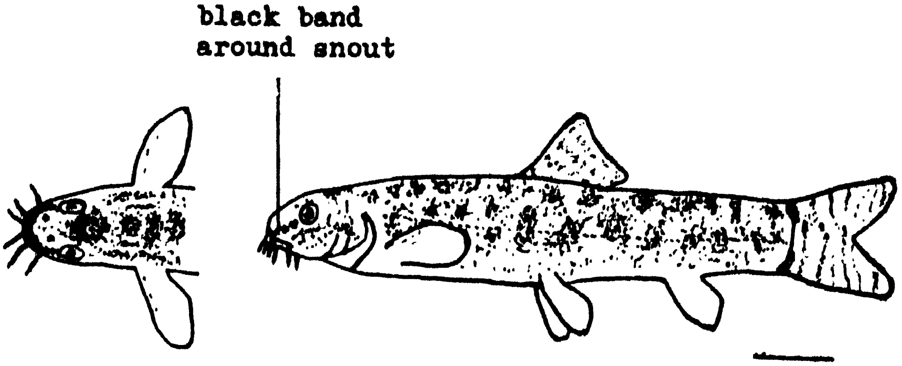


Figure 27. Nemachilus frenata



a little less high than the dorsal, does not reach the caudal. Dorsal fin rays: 3 simple, 8 or 9 branched; anal fin rays, 2 simple, 5 branched. The pectoral is 3/4 the length of the head, and goes beyond 1/2 the distance from the origin of the pelvic. The pelvic fin is inserted a little back of the origin of the dorsal. The caudal peduncle is 1 1/3 times as long as high. The caudal is emarginate.

Color: General coloration is yellowish white with 10 - 12 lateral brown bars more or less interrupted by a longitudinal silver line. The head is brown on top, clear underneath, with small dark spots on the sides and a dark line going nearly from the eye to the extremity of the snout. The end of the caudal peduncle is black barred. The dorsal and caudal fins are more or less barred or spotted with dark color.

This fish has been collected in the Orontes, Khebir, Afrin and Banias Rivers. Little is known of its life history.

Nemachilus frenata (Heckel)

Caudal fin slightly emarginate. Origin of the dorsal fin nearly midway between the end of the snout and the root of the caudal. The height of the body is scarcely less than the length of the head, which is nearly one-fifth of the standard length. Snout short, obtuse, much shorter than the postorbital portion of the head. Eye rather small. Length of the pectoral about one-half of the distance of its base from the ventral. Upper margin of the dorsal fin straight, not very oblique. Dorsal fin rays, 3 simple, 8 branched; anal rays, 2 simple, 5 branched.

Color: Body generally yellowish in color, finely mottled in irregular spots with brown. A distinct brown spot at upper and lower bases of caudal fin. Caudal and dorsal fins irregularly banded with brown spots. A dark band from eye to eye around end of snout.

This fish was collected from the Kueik River and the Ouadi Khneiser. Little is known of its life history.

Nemachilus galilaeus (Gunther)

Caudal fin slightly emarginate. The origin of the dorsal fin is somewhat nearer to the end of the snout than to the root of the caudal. The height of the body is considerably less than the length of the head, which is contained 5 times to 5 1/4 in the standard length. Snout is of moderate length, a little shorter than the postorbital portion of the head. Eye small, with a free circular eyelid, its diameter not being quite as wide as the interorbital space. Length of the pectoral more than one-half of the distance of its base from the pelvic. Upper margin of the dorsal fin straight, oblique. Dorsal ray count 3 simple, 9 branched; anal rays 2 simple, 6 branched.

Color: Body generally yellowish, and finely mottled with brown. Four brown crossbars on the back before, and four brown crossbars on back behind the dorsal fin.

This fish is reported from the Lake Tiberias and was taken from Muzerib Spring. Little is known of its life history.

Nemachilus insignis (Heckel)

Caudal fin conspicuously emarginate. Origin of the dorsal fin midway between the end of the snout and the root of the caudal. The height of the body is considerably less than the length of the head, which is 1/5 of the standard length. The depth of the free portion of the tail is one-half of its length. Snout produced, rather pointed, its length being more than that of the post-orbital portion of the head. Eye of moderate size, its diameter being a little less than the width of the inter-orbital space. Length of the pectoral fin rather more than 1/2 the distance of its root from the pelvic. Upper margin of the dorsal fin straight, oblique. Dorsal rays 3 simple, 7 branched; anal rays 2 simple, 5 branched.

Color: Body generally yellowish, sides and back mottled with dark brownish or black, belly plain. Usually one dark band across the dorsal fin.

This fish has been taken in the Kueik, Abyad and Afrin Rivers. Little is known about its life history.

Figure 28. Nemachilus galilaeus

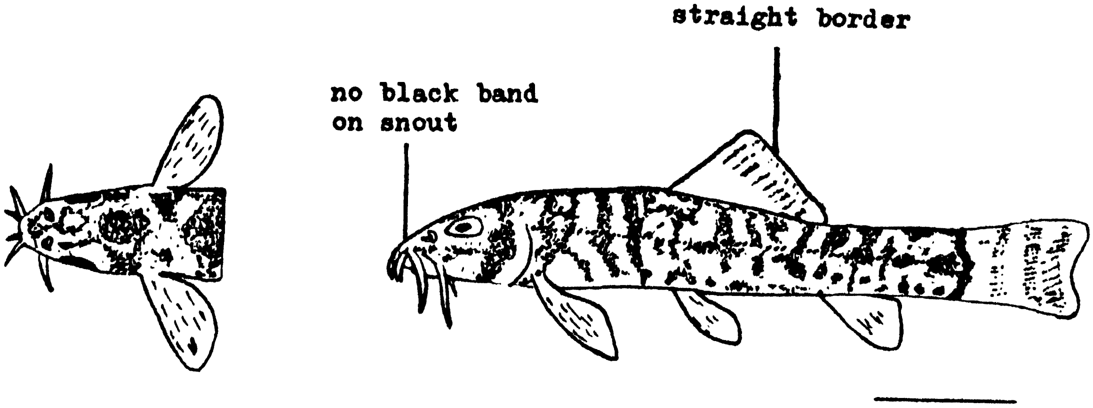
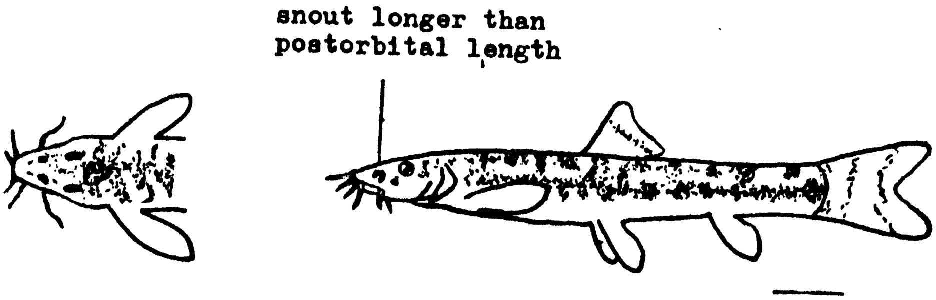


Figure 29. Nemachilus insignis



Nemachilus panthera (Heckel)

Caudal fin slightly emarginate. Origin of the dorsal fin farther from the end of the snout than the root of the caudal. The height of the body is less than the length of the head, which is 2/9, or rather more than 1/5, of the standard length. Snout of moderate length, obtuse, somewhat shorter than the postorbital portion of the head. Eye small. Length of the pectoral fin more than 1/2 of the distance of its root from the pelvic. Upper margin of the dorsal fin convex. Dorsal rays 3 simple, 7 branched; anal rays 2 simple, 5 branched.

Color: Body generally yellowish, with small densely crowded irregular black spots and dots (resembling the spotting of the panther, hence its name); sometimes a black vertical spot on the root of the caudal. Spots on all fins but the pelvics.

This fish has been taken from the waters about Damascus and the spring of Muzerib. Little is known of its life history.

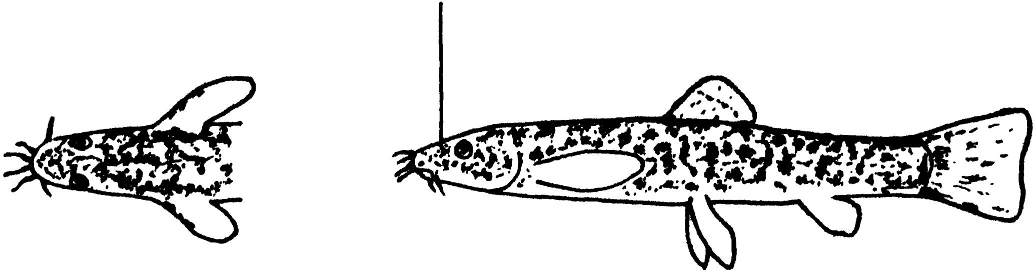
Nemachilus tigris (Heckel)

Caudal fin slightly emarginate. Origin of the dorsal fin nearly midway between the end of the snout and the root of the caudal. The height of the body is somewhat less than the length of the head, which is 1/5 of the standard length. Snout of moderate length, obtuse, a little shorter than the postorbital distance of the head. Eye small. Length of the pectoral more than 1/2 of the distance of its base from the pelvic. Upper margin of the dorsal fin straight, nearly horizontal. Dorsal rays: 3 simple, 8 branched; anal fin: 2 simple, 7 branched.

Color: Body generally yellowish with 15 or more narrow, irregular crossbars extending onto belly. Dorsal generally with a broad dark band, caudal fin generally with 2 dark bands. Usually a black band across base of caudal peduncle.

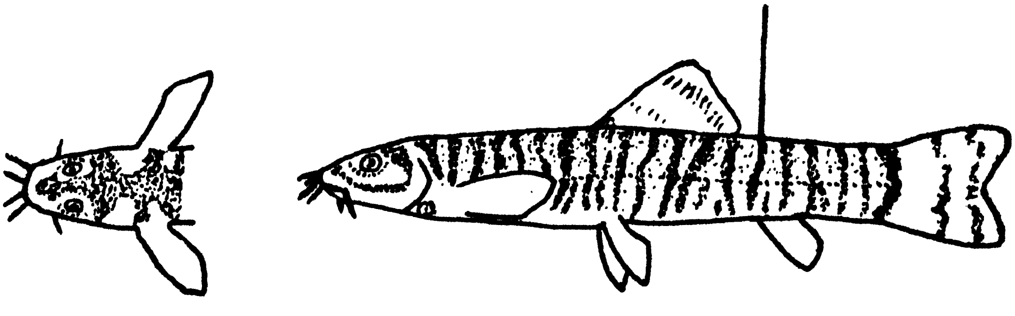
This species has been taken from the waters about Damascus, from the Orontes, Nahr el Riz, Yabroud and the Jarrah Rivers. Little is known of its life history.

Figure 30. _Nemachilus_ _panthera_



snout shorter than postorbital length, no black band on snout

Figure 31. _Nemachilus_ _tigris_



more than 15 bars

FAMILY CYPRINIDAE

Body generally covered with cycloid scales, head naked; form varied, elongate and subfusiform, more or less compressed, or sometimes thin and deep; pelvic abdominal; Weberian apparatus present; no adipose fin; branchiostegals always 3; margin of upper jaw formed by premaxillaries alone; jaws toothless; lower pharyngeal bones well developed, falciform, and nearly parallel with gill arches, each armed with 1 to 3 series of teeth, 3 to 7 in main row, and a lesser number in the others; stomach without appendages; air bladder typically present and with an open duct, commonly divided into two more or less distinct chambers.

This family is represented by 14 genera in Syrian waters. Because of the difficulty in identifying the members of this family two different keys are provided. For beginners especially the determination of the presence or absence of the keel may be difficult on small specimens, and also the removal of the pharyngeal teeth presents difficulties. Thus at the beginning it might be well to run the specimens through both keys until familiarity with the group is obtained.

Key to the Genera of CYPRINIDAE

1 a. Cheek below eye covered by silvery bone; lateral line parallel to ventral outline on caudal peduncle .... *Barilius*

1 b. Cheek not covered by silvery bone below eye; lateral line running along middle of caudal peduncle

2 a. No keel between vent and pelvic fins

3 a. A disk behind the lower jaw .... *Garra*

3 b. No disk behind the lower jaw

4 a. Dorsal fin with enlarged bony ray

5 a. Lower jaw with horny covering

6 a. Dorsal fin with more than 12 branched rays .... *Cyprinion*

6 b. Dorsal fin with less than 13 branched rays .... *Varicorhinus*

5 b. Lower jaw without horny covering
  7 a. Dorsal fin with more than 15 branched rays .... *Cyprinus*
  7 b. Dorsal fin with less than 12 branched rays .... *Barbus*
4 b. Dorsal fin without enlarged bony ray
  8 a. Anal fin with less than 6 branched rays .... *Tylognathus*
  8 b. Anal fin with more than 5 branched rays
    9 a. Mouth with horny jaw covering .... *Chondrostoma*
    9 b. Mouth without horny jaw covering
      10 a. More than 90 scales in lateral line .... *Aspius*
      10 b. Less than 80 scales in lateral line
        11 a. No scaled appendage at base of pelvics .. *Phoxinellus*
        11 b. Scaled appendage at base of pelvics
          12 a. Pharyngeal teeth in one row .... *Rutilus*
          12 b. Pharyngeal teeth in two rows .... *Leuciscus*
2b. A keel between vent and pelvic
  13 a. An enlarged bony ray in dorsal fin .... *Acanthobrama*
  13 b. No enlarged bony ray in dorsal fin .... *Alburnus*

Second Key to the Genera of CYPRINIDAE

1 a. A disk behind lower jaw .... *Garra*
1 b. No disk behind lower jaw
  2 a. Dorsal fin with long base, 17-22 branched rays .... *Cyprinus*
  2 b. Dorsal fin with short base, less than 12 branched rays
    3 a. Pharyngeal teeth in two rows
      4 a. More than 90 scales in lateral line .... *Aspius*
      4 b. Less than 80 scales in lateral line
        5 a. Anal fin with more than 12 branched rays ..... *Alburnus*
        5 b. Anal fin with less than 13 branched rays ..... *Leuciscus*
    3 b. Pharyngeal teeth in one or three rows
      6 a. Pharyngeal teeth in one row

7 a. Mouth inferior, lower jaw with horny layer .... *Chondrostoma*

7 b. Mouth terminal, lower jaw without horny layer

8 a. Dorsal fin with osseous spine .... *Acanthobrama*

8 b. Dorsal fin without osseous spine

9 a. More than 8 branched rays in anal fin ..... *Rutilus*

9 b. Less than 9 branched rays in anal fin ..... *Phoxinellus*

6 b. Pharyngeal teeth in three rows

10 a. Dorsal fin with more than 12 branched rays ... *Cyprinion*

10 b. Dorsal fin with less than 13 branched rays

11 a. No enlarged bony ray in dorsal fin

12 a. Cheek covered by silvery bone, no rostral flap .... *Barilius*

12 b. Cheek not covered by silvery bone, rostral flap present .... *Tylognathus*

11 b. Enlarged bony ray in dorsal ray

13 a. No horny covering on lower jaw .... *Barbus*

13 b. Horny covering on lower jaw .... *Varicorhinus*

Genus *Acanthobrama* Heckel

Scales small; lateral line running nearly in the middle of the tail. Dorsal fin short, with the third ray enlarged, osseous and smooth, inserted behind the pelvics. Anal fin many rayed. Mouth anterior or subanterior. Barbels none. Pharyngeal teeth 5-5, compressed.

This genus is represented by 4 species in Syrian waters.

Key to the Species of *Acanthobrama*

1 a. More than 90 scales in the lateral line .... *A. centisquama*
1 b. Less than 90 scales in the lateral line
  2 a. Anal soft rays more than 15 .... *A. marmid*
  2 b. Anal soft rays less than 16
    3 a. Less than 70 scales in lateral line; less than 15 rows of scales between the lateral line and origin of the dorsal fin .... *A. lissneri*
    3 b. More than 69 scales in lateral line; more than 14 rows of scales between the lateral line and origin of the dorsal .... *A. terrae-sanctae*

Acanthobrama centisquama (Heckel)

The height of the body is 2/7 the standard length. Snout slightly projecting beyond the mouth, which is oblique and extending backwards to below the nostrils. Dorsal spine strong, long, and smooth, as high as the body. Dorsal fin with 3 simple and 8 branched rays. Pectoral fins reaching the pelvics. Anal fin with 22 rays. Scales without radiating striae. Lateral line slightly arched. There are 10 longitudinal series of scales between the lateral line and the ventral fin.

Color: Uniformly whitish or silverish.

Figure 32. Acanthobrama centisquama

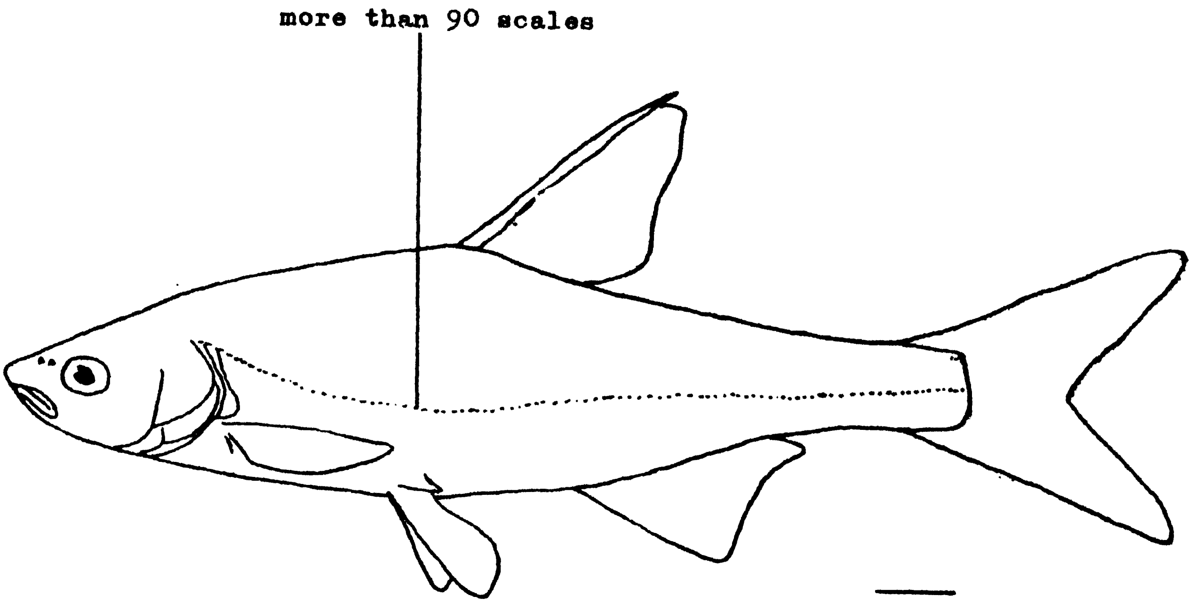
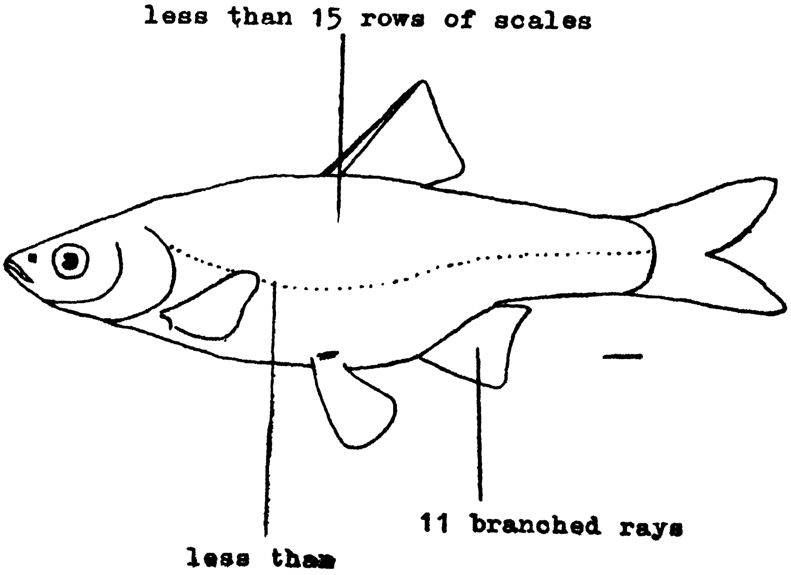


Figure 33. Acanthobrama lissneri



Acanthobrama lissneri Tortonese

Body compressed, with the dorsal outline a little more arched than the ventral one; maximum height just at origin of dorsal fin. Snout acutely rounded. Mandible a little shorter than the upper jaw. Eye diameter 1/3 of the head, almost equal to height of the snout. Mouth cleft reaching below the nostrils. Pharyngeal teeth 5 - 5, smooth and hooked. Caudal peduncle as deep as the length of the postorbital part of the head. Lateral line regularly arched downwards, ending in the middle of the tail; 60 tubules. 10 series of scales between the origin of the dorsal fin and the lateral line, 5 between the latter and the base of the ventral fins. Dorsal rays 3 simple, 7 branched, the third simple ray like a feeble spine, shorter than the height of the body. The anterior border of the dorsal fin is as long as the distance from the nostrils to the posterior border of the opercle, and about equal to the length of the caudal lobes. Anal fin originating behind the posterior end of the dorsal; its rays 3 simple, 11 branched. Pectorals as long as the distance from the anterior border of the eye and the posterior border of the opercle, not extending under the dorsal, nor to the pelvics. The pelvics are a trifle shorter, are inserted a little before the vertical from the origin of the dorsal fin and reach the origin of the anal.

Color: Uniformly silverish, with a trace of a grey band running along each side well above the lateral line.

This species is found in Lake Tiberias.

Acanthobrama marmid Heckel

The height of the body is nearly 1/3 of the standard length. Snout obtuse, bent downwards to the mouth, which is but slightly oblique, extending backwards to below the nostrils. Dorsal spine rather feeble, smooth. Lateral line slightly bent downwards. There are 6 rows of scales between the lateral line and the ventral fin. There are 65-70 scales in the lateral line. Dorsal fin rays 3 simple, 8 branched; anal rays 3 simple, 16 branched.

Color: Generally silverish or whitish.

This fish was taken from the Jarrah and Ouadi Khneizer in the Khabour Drainage.

Figure 34. *Acanthobrama marmid*

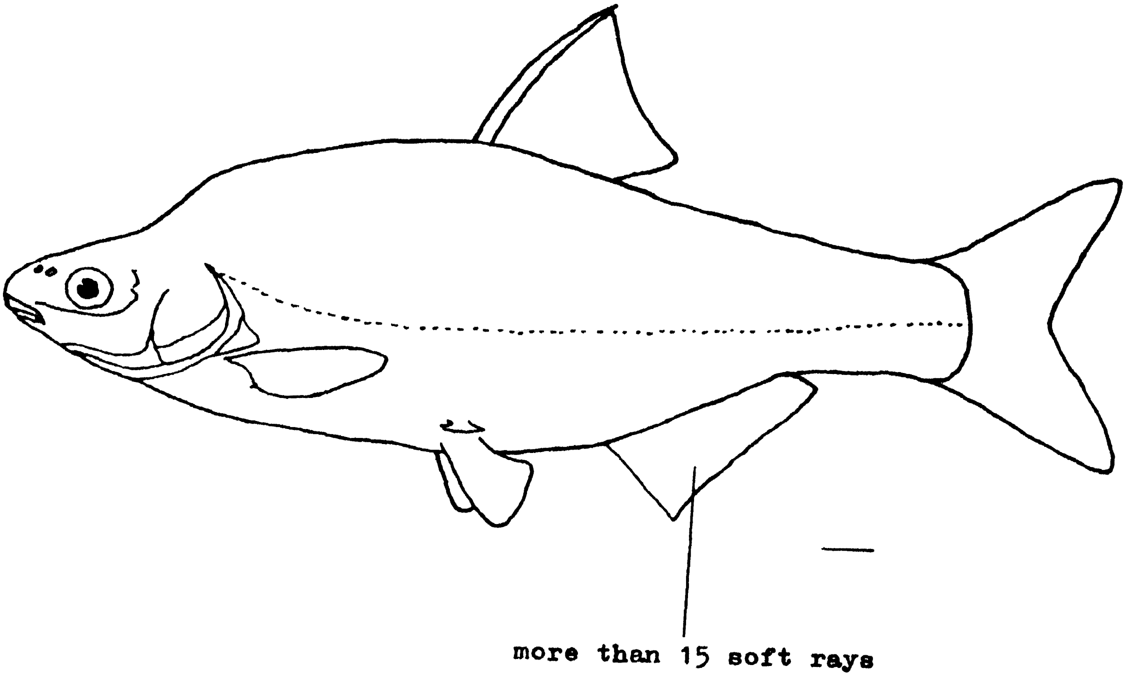
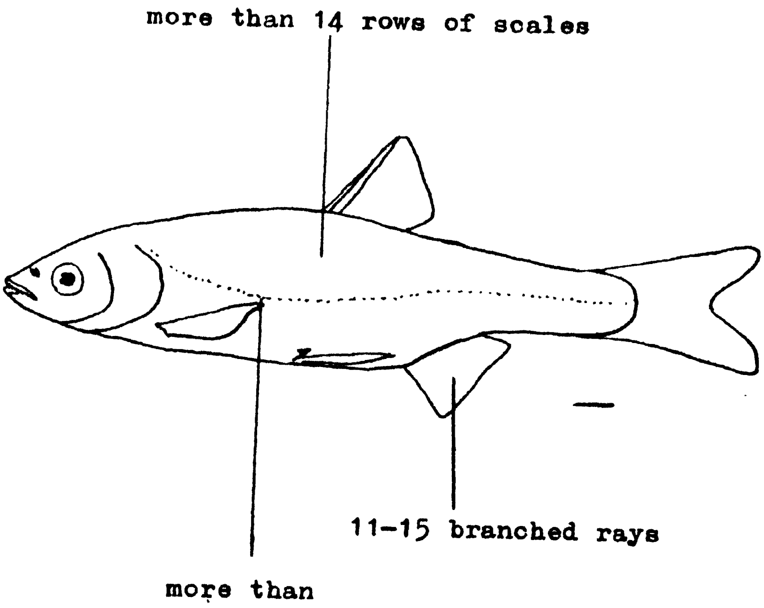


Figure 35. *Acanthobrama terrae-sanctae*



Acanthobrama terrae-sanctae Steinitz

The body is elongated, compressed. Head is contained in standard length 3.9 to 4.2; height, 4.2 to 4.4. Snout profile almost straight and flat. Main part of protuding mandible fits into the upper jaw which is narrowly curved from side to side. Chin prominent. Maxillary hidden when mouth closed. 17 gill rakers on first arch. Pharyngeal teeth 5 - 5. Dorsal fin rays 3 simple, 7-9 branched; anal rays 3 simple, 11-15 branched. Lateral line scales 70-82; scales above lateral line 15 - 16; scales below lateral line 6 - 8. Third dorsal spine strongly ossified. Pelvic fins not reaching anus. Between pelvic fins and extending to anus a sharp ridge of scales is present. Anal fin origin behind posterior end of dorsal. Caudal deeply forked, lower lobe the longest.

Color: Generally silvery, upper half of body darker than lower, sometimes shining with steel blue. Opercle with dark spot near anterior border. Skin of opercle flap generally yellowish tinted. A yellowish tinge also usually present at base of anal and pelvic fin, and on central caudal rays. This color becomes much brighter during breeding season, may become yellow-orange.

This species is found in the Spring of Muzerib and in Lake Tiberias from which is was but recently described. Nothing is known of its life history.

Genus Alburnus Heckel

Body compressed, more or less elongate; scales moderate; mouth medium, simple lips, no barbels, directed upwards, labial fold interrupted at the symphysis of the mandible; Lower jaw projecting beyond upper; upper jaw protractile. Suborbitals small. Cheeks naked. Pharyngeal teeth in two rows, hooked, generally 2,5 - 5,2. Lateral line complete, nearer belly than back, median on caudal peduncle. Belly rounded before and after pelvics, cutting in back of the latter. Dorsal fin short, without ossified rays, origin in back of pelvics. Anal long, formed of 3 simple rays, 16 - 20 branched rays. Gill rakers slender, lanceolate, closely set; pseudobranchiae present. The attachment of the branchial membrane to the isthmus below posterior margin of orbit. Belly behind pelvics to anus compressed into an edge, not covered by scales. A scaled appendage at base of the pelvics.

This genus is represented by six species in Syrian waters.

Key to the Species of Alburnus

1 a. Less than 70 scales in the lateral line
  2 a. Less than 61 scales in the lateral line
    3 a. Less than 17 anal rays .... A. orontis
    3 b. More than 16 anal rays .... A. caeruleus
  2 b. More than 60 scales in the lateral line
    4 a. Origin of anal behind vertical of last rays of dorsal; anal rays less than 16 .... A. capito
    4 b. Origin of anal in advance of vertical from last ray of dorsal; anal rays more than 15 ..... A. pallidus
1 b. More than 69 scales in the lateral line
  5 a. Pectoral fins terminating well before pelvics ..... A. sellal
  5 b. Pectoral fins almost reaching pelvics .... A. mossulensis

Alburnus caeruleus Heckel

Body rather elevated, its depth being 1/3 of the standard length. snout a little shorter than eye; cleft of mouth directed upwards, with jaws nearly even in front. Lateral line 48-50 scales, 4 rows of scales between lateral line and pelvic fin. Anal fin origin before vertical from last ray of dorsal fin. Dorsal fin 2 simple, 9 branched; anal rays 18-19.

Color: Body silvery white, back slightly darker, sides often minutely flecked with black. A dark mid-dorsal stripe. A grayish band along the side of the body. Vertical fins deep black toward their extremities.

This species was taken in the Kueik, Khabour and tributaries and the Tigris river. Little is known of its life history.

Figure 36. *Alburnus caeruleus*

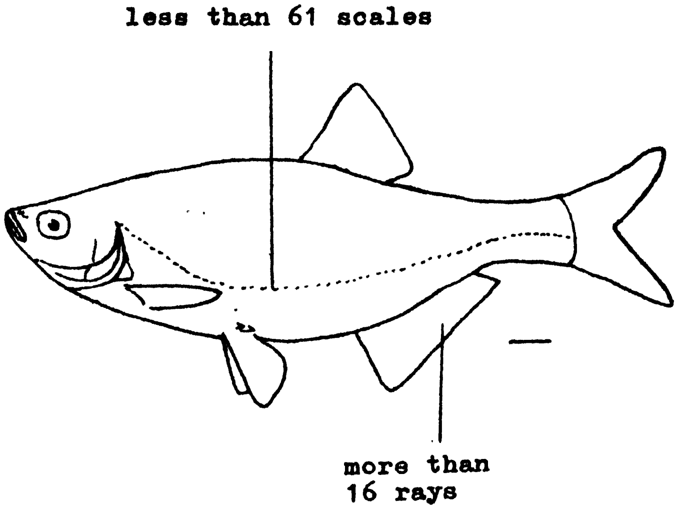
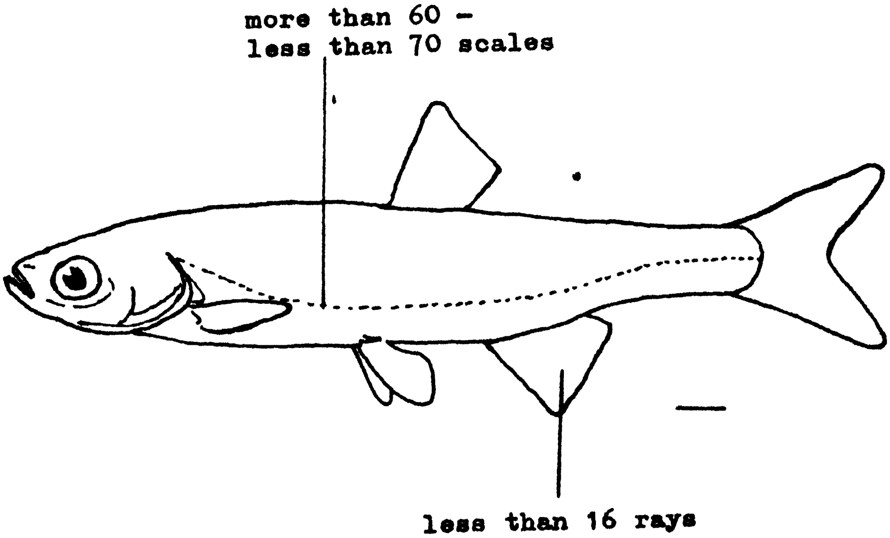


Figure 37. *Alburnus capito*



Alburnus capito Heckel

Body rather elongate, its depth being one-fifth the standard length; the length of the head is contained four times and one-third in the standard length. Snout rather shorter than the eye. Cleft of mouth directed upwards; the lower jaw projecting beyond the upper. Lateral line scales 65; 5 rows between lateral line and pelvic fin. Dorsal fin rays 2 simple, 9 branched; anal fin rays 14. Origin of anal behind vertical from last dorsal ray. Pectoral terminating at some distance from origin of pelvic.

Color: Back dusky, with a darkish lateral band about 1/3 from top. Sides and belly below band silvery white.

This species was also taken in the Kueik and Tigris Rivers and Lake Tiberias. Little is known of its life history.

Alburnus mossulensis Heckel

Body rather elongate, its depth being contained 4 3/4 times in standard length. Snout a little longer than the eye; cleft of mouth directed upwards; lower jaw projecting beyond the upper. Lateral line scales 75-78; 5 rows between lateral line and pelvic. Anterior anal rays behind vertical from last ray of dorsal. Pectorals nearly reaching the origin of the pelvics. Dorsal fin rays, 2 simple, 9 branched; anal rays, 15.

Color: Generally silvery white, with a lead-colored band along lateral line and above it.

This fish was taken from the Euphrates and Khabour Rivers. Nothing is known of its life history.

Alburnus orontis Sauvage

Height of body contained 4 1/2 times in the total length; length of head 5 1/3 in same dimension. Snout of same length as the eye, whose diameter is contained 3 1/2 times in the head length. Interorbital space almost as wide as eye diameter; mouth opening oblique; inferior jaw slightly exceeding the superior. Dorsal terminates even with the base of the anal, situated nearer the caudal peduncle than the anterior border of the orbit. Dorsal rays 2 simple, 9 branched; anal rays 13-15; anal less high than dorsal. Pectorals as long as head. Lateral line scales 52-60,

Figure 38. Alburnus mossulensis

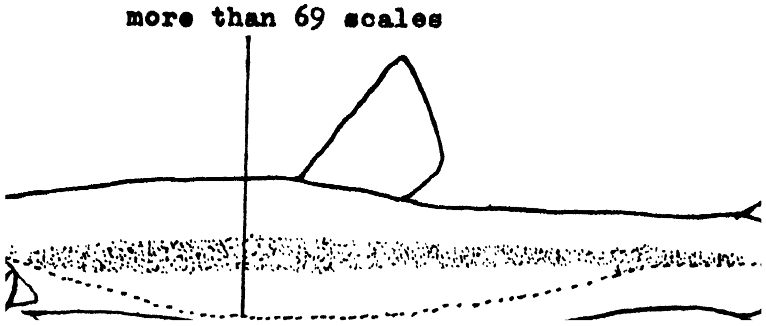
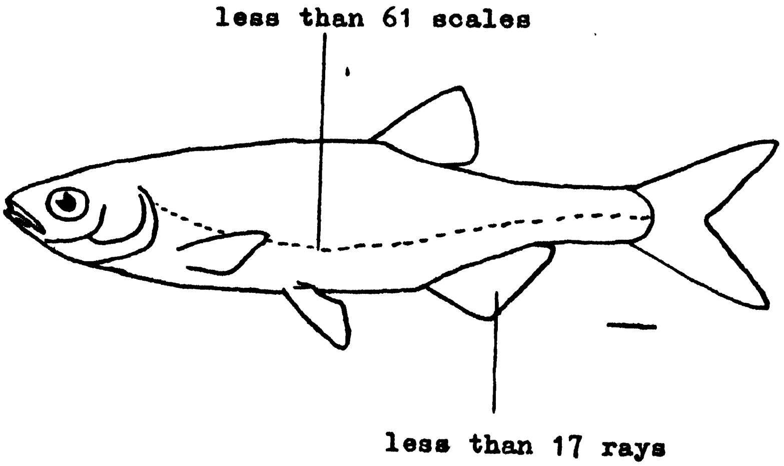


Figure 39. Alburnus orontis



11 between dorsal and lateral line, 5 from lateral line to pelvic.

Color: Back olivaceous, a dark lateral band about 1/3 below top of back. Sides and belly silvery white.

This species is found in the Orontes, Abyad, Afrin, Kueik and Khebir Rivers. Little is known of its life history, except that it lives in schools and feeds upon plankton. It may attain a length of 150 mm.

Alburnus pallidus Heckel

Body rather elongate, its depth being contained 3 3/4 times in standard length. Cleft of mouth directed upwards, lower jaw scarcely projecting beyond upper. Lateral line scales 64; with 4 rows of scales between lateral line and pelvic fin. Dorsal rays 2 simple, 9 branched; anal rays 17. Origin of anal fin in advance of vertical from last dorsal ray. Pectorals extending nearly to the root of the pelvics.

Color: Uniformly silvery white.

This species was taken from the Euphrates and Kueik Rivers and from the Soutane, a tributary of the Tigris. Little is known of its life history.

Alburnus sellal Heckel

The length of the head is slightly shorter than the height of the body; it is contained 4 1/4 times in the standard length. The mouth is small and the inferior jaw is hidden beneath the upper. The eye is large, its diameter measures 1/3 the length of the head, it is nearer the preopercle border than the tip of the snout. The interorbital distance equals the eye diameter. The origin of the dorsal is at the highest point of the dorsal line, it is equal distant from the tip of the snout to the origin of the caudal. The caudal is deeply notched and is sloped at a sharp angle. The pectoral is rather long and wide, reaching the fourth row of scales in front of the pelvics. The pelvics are narrow and reach, when erect, the anal opening. The anal is wide but rather low in the back, ending an equal distance from the anus and root of the caudal. Dorsal fin rays 2 simple, 8 branched;

Figure 40. Alburnus pallidus

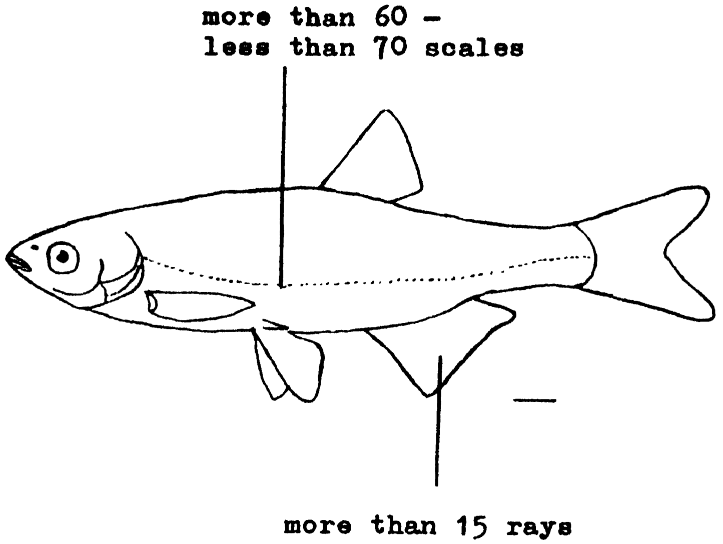
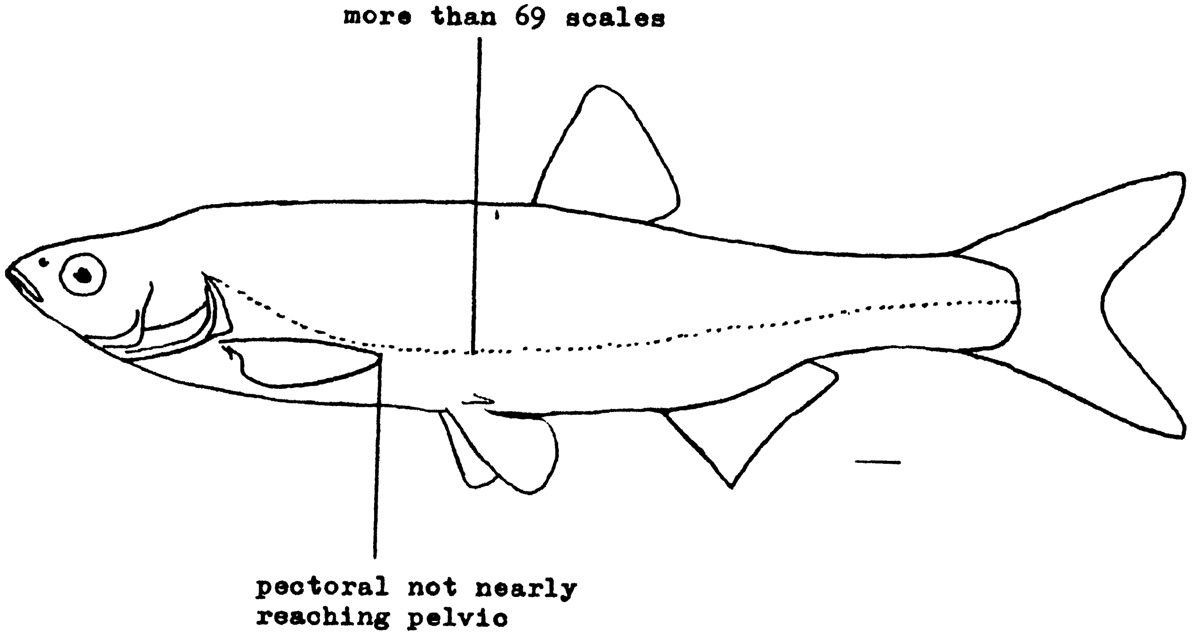


Figure 41. Alburnus sellal



anal rays 15; lateral line scales 73-80, 5 rows between lateral line and pelvic. Scales on anterior part of trunk with minute black dots at the base. Anal origin behind vertical from last ray of dorsal.

Color: Back yellowish-gray to reddish brown, slate colored band along side above lateral line. The belly and sides silvery white. Cheeks are silvery, fins greenish silvery.

This fish was taken in the Kueik River, and may attain a length of 150 mm.

Genus Aspius Agassiz

Body more or less compressed, elongate, covered with moderate scales. Lateral line complete. Mouth large, terminal, with simple lips, no barbels, lower labial fold interrupted at the symphysis. Lower jaw more or less conspicuously projecting beyond the upper. Cheeks naked. Pharyngeal teeth in two rows, generally 3, 5 - 5, 3; pointed and hooked. Gill rakers short and widely set. Dorsal short, without ossified rays, composed of 3 simple and 8 to 10 branched rays, and originating behind pelvics. Anal rather long, formed by 3 simple and 12-15 branched rays. Scaled appendage at base of pelvics.

One species represents this genus in Syria.

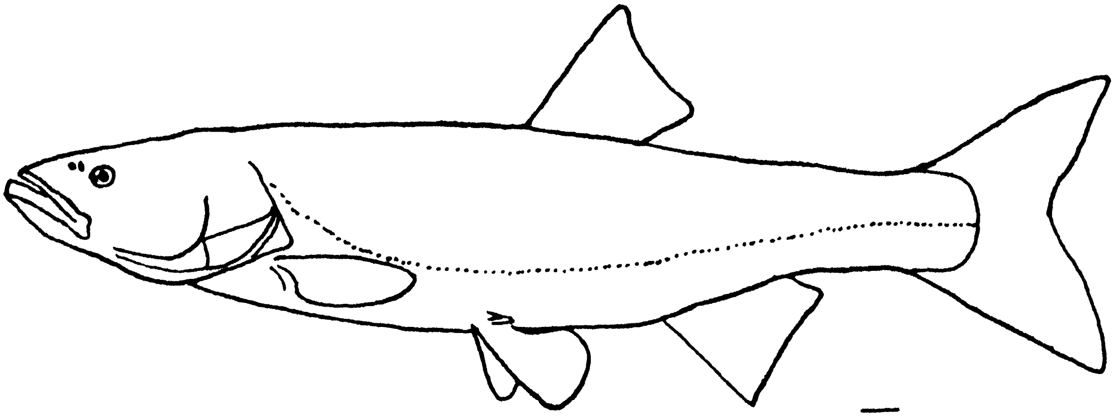
Aspius vorax Heckel

Cleft of mouth wide, with the lower jaw much projecting beyond the upper. Eye small. The length of the head is 1/4 of the standard length. The origin of anal fin is immediately behind the dorsal. The hindmost suborbital is nearly as large as the preorbital, the intermediate bones being narrow. The dorsal fin with 3 simple, 8 branched rays; the anal rays 3 simple, 13 branched. Lateral line scales 94-105, with 18 rows above the lateral line and 10 rows between lateral line and pelvic.

Color: Generally uniformly silvery gray.

This fish was taken from the Tigris and the Orontes Rivers.

Figure 42. Aspius vorax



Genus *Barbus* Cuvier

Body more or less compressed, covered with small, moderate or large scales. Lateral line, if present, usually nearer belly than the back, but always running along the middle of the caudal peduncle. Mouth small or moderately large, more or less protractile, with more or less developed lips; barbels present or absent. Suborbitals not covering cheek. Dorsal fin with or without ossified ray, with 9 to 14 rays, 6 to 11 of which are branched. Anal fin short with 7 to 10 rays. A scaly process usually present at base of ventral fin. Pharyngeal teeth in 3 series - 2 or 3, 3, 4 or 5 -- 5 or 4, 3, 3 or 2., mostly with hooked, spoon-shaped crowns, one or more of the anterior of the inner series often molariform or mammilliform.

In Syrian waters there are 17 species representing this genus.

Key to the Species of *Barbus*

1 a. Four barbels present
  2 a. Scales small or moderate, more than 39 in lateral line
    3 a. Dorsal spine serrate
      4 a. Scales in lateral line more than 69
        5 a. Scales in lateral line more than 78; large spots on body .... *B. subquincuniatus*
        5 b. Scales in lateral line less than 79; no spots on body .... *B. esocinus*
      4 b. Scales in lateral line less than 70
        6 a. Scales in lateral line more than 57
          7 a. Scales above lateral line in less than 11 rows .... *B. xanthopterus*
          7 b. Scales above lateral line in more than 11 rows
            8 a. Body mottled with black spots ..... *B. lacerta*
            8 b. Body not mottled .... *B.rajanorum*

6 b. Scales in lateral line less than 58

9 a. Dorsal spine finely serrate; body mottled with dark spots .... *B. scincus*

9 b. Dorsal spine strongly serrate; body not mottled with dark spots

10 a. Less than 51 scales in lateral line .... *B. pectoralis*

10 b. More than 50 scales in lateral line

11 a. Short lobule at symphysis of lower lip .... *B. barbulus*

11 b. No lobule at symphysis of lower lip

12 a. Snout obtuse, body compressed elevated ...... *B. kersin*

12 b. Snout long, pointed; body rather elongated .... *B. longiceps*

3 b. Dorsal spine smooth

13 a. Less than 45 scales in lateral line .... *B. grypus*

13 b. More than 44 scales in lateral line

14 a. More than 54 scales in lateral line .... *B. lorteti*

14 b. Less than 55 scales in lateral line .... *B. orontis*

2 b. Scales large, less than 40 in lateral line

15 a. More than 29 scales in lateral line .... *B. canis*

15 b. Less than 30 scales in lateral line .... *B. chantrei*

1 b. Two or no barbels present

16 a. One pair of barbels present .... *B. luteus*

16 b. No barbels present .... *B. sharpeyi*

Barbus barbulus Heckel

Third dorsal spine strong, serrated, of moderate length; the dorsal fin, if laid backwards, extends scarcely to the origin of the anal. Body rather elongate. Mouth inferior; lower lip very broad, with a very short lobule at the symphysis. Dorsal fin rays, 2 or 3 simple, 8 branched; anal fin rays 2 or 3 simple, 5 or 6 branched. Lateral line scales 52-54; 10 rows above lateral line, 7 rows between lateral line and pelvic.

Color: Back and upper sides brownish, lower sides lighter yellowish, belly whitish.

This fish was taken from the Euphrates River. It is primarily a river fish, and feeds upon bottom organisms and detritus principally.

Figure 43. Barbus barbulus

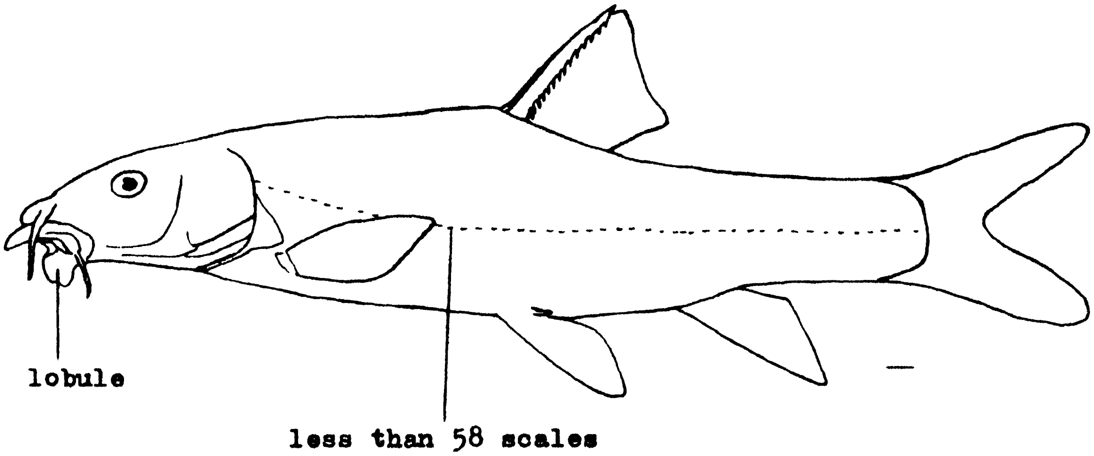
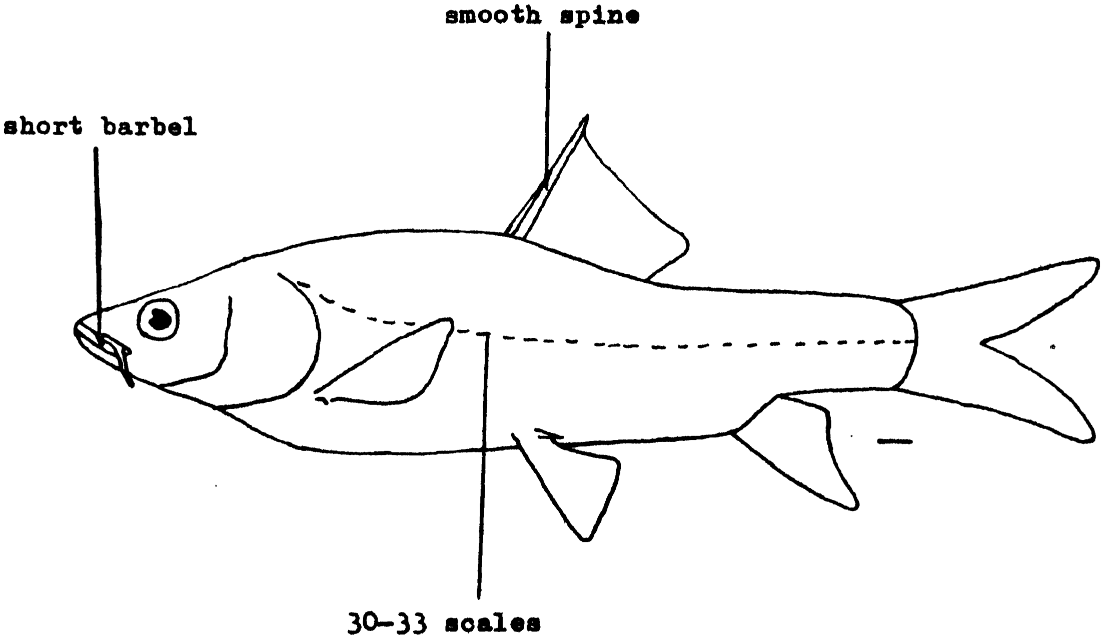


Figure 44. Barbus canis



Barbus canis Cuvier and Valenciennes

Body compressed, moderately elongate, with the profile of the back arched; its depth equals the length of the head, and is contained 3 1/3 to 3 1/2 times in the standard length; head rather large, its depth equal to its length, without the snout. Eye rather small, much shorter than the snout, even in young. Mouth anterior, the jaws being equal or subequal in length in half-grown specimens, and the lower jaw slightly projecting beyond the upper in old ones. Lips thin, the transverse fold of the lower interrupted in the middle; barbels small. Origin of dorsal fin opposite that of the pelvics, and nearer the root of the caudal than the end of the snout. Osseous dorsal ray rather feeble, smooth, its stiff portion being one-third to one-half as long as head. Dorsal fin rays 2 or 3, 8 or 9 branched; anal rays 2 or 3 simple, 5 or 6 branched. Lateral line scales 32-33; 4 rows above lateral line and 4 rows below.

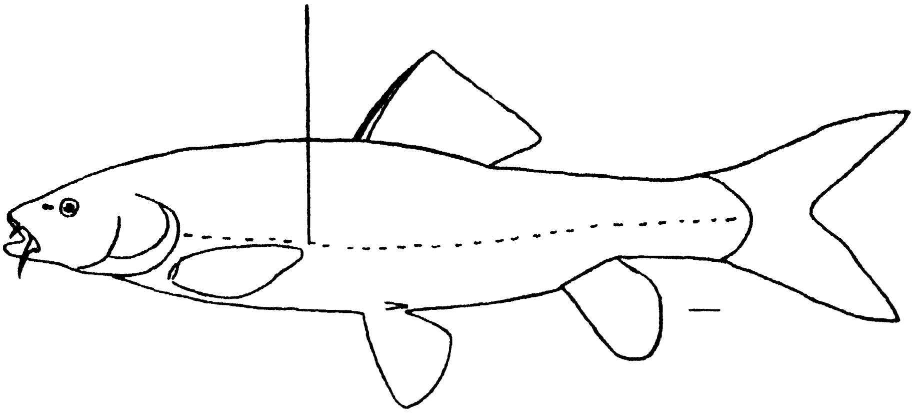
Color: Back and upper sides dark olive brown, belly lighter yellowish to silvery white. Trace of dark lateral band, especially on the caudal peduncle.

This fish was taken from Lake Tiberias, the Orontes, Afrin, Yarmuk Rivers and Muzerib Springs. One specimen was a near ripe individual and the eggs were counted to the number of 5,431. This specimen was about 25 centimeters in length. Its life history is not known.

Barbus chantrei Sauvage

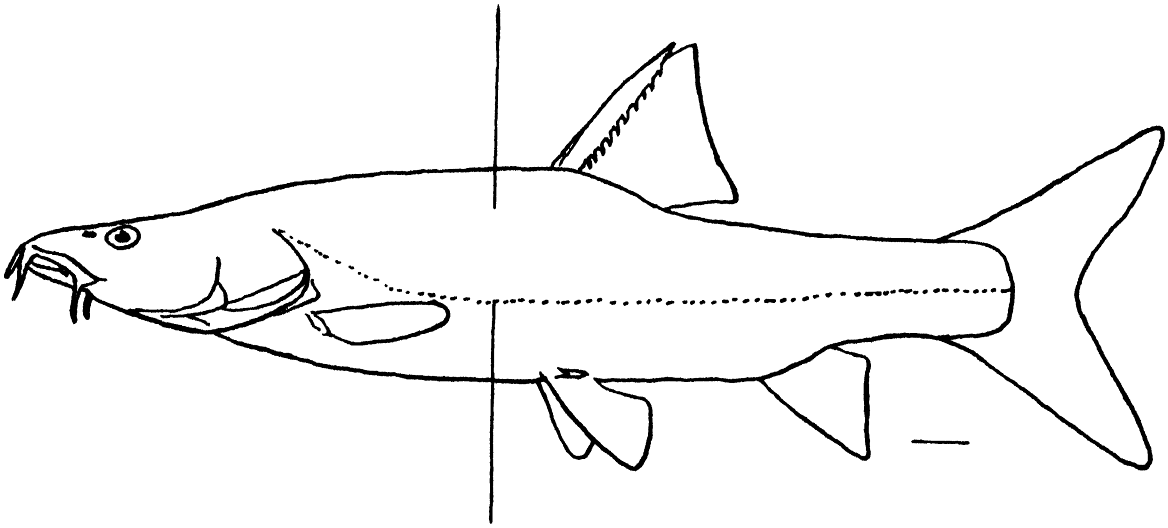
Body elongated, the height contained 4 2/3 in the total length; length of head 5 2/3 in the same dimension. Four barbels, the superior short, the inferior but little more than half the length of the eye. Mouth terminal; snout thick, obtuse, 1 2/3 times as long as the eye, whose diameter is contained 6 times in the length of the head; the interorbital space convex, 2 2/3 times as wide as the diameter of the eye; forehead sloping. Dorsal inserted a little nearer the extremity of the snout than the base of the caudal; third ray feeble; fin scarcely truncated, 1 1/2 times as long as high. Caudal moderately notched, contained 5 1/2 times in length of body. Anal higher than

Figure 45. *Barbus chantrei*



less than 30 scales

Figure 46. *Barbus esocinus*



body not spotted

more than 69 -
less than 79 scales

the dorsal, less than 2 times as high as long. Pectoral longer than pelvics. Dorsal rays 2 simple, 13 branched; anal rays, 10. Lateral line scales, 25.

Color: Body olive brownish on back, lower sides lighter yellowish to whitish. Darker on head, and extremities of pectorals, pelvics and anal brownish.

Nothing is known of its life history.

This fish was taken from the Khabour River.

Barbus esocinus (Heckel)

Body rather compressed. Snout produced, subconical, with the jaws nearly equal in length, the mouth being anterior; lips but little fleshy. Eyes very small. Anal fin twice as high as broad. Dorsal fin with third spine strong and serrated. Caudal fin deeply forked. Lateral line scales 76 - 78; 12 rows of scales between lateral line and base of pelvic. Dorsal fin rays, 8 branched rays; anal fin, 5 branched rays.

Color: Generally olivaceous on the back with numerous scattered black dots. Sides and belly lighter.

This fish is reported from the Tigris River and from the Euphrates. It is reportedly a predator and reaches a length of 50 centimeters. It lays its eggs in between big stones in the deep parts of the river. It spawns in March or April.

Barbus grypus Heckel

Body rather elongate, sub-cylindrical. Snout not produced, with the mouth inferior, and with the lips thick, the lower with a continuous transverse fold. Eye rather small. Lateral line scales 40.

Figure 47. Barbus grypus

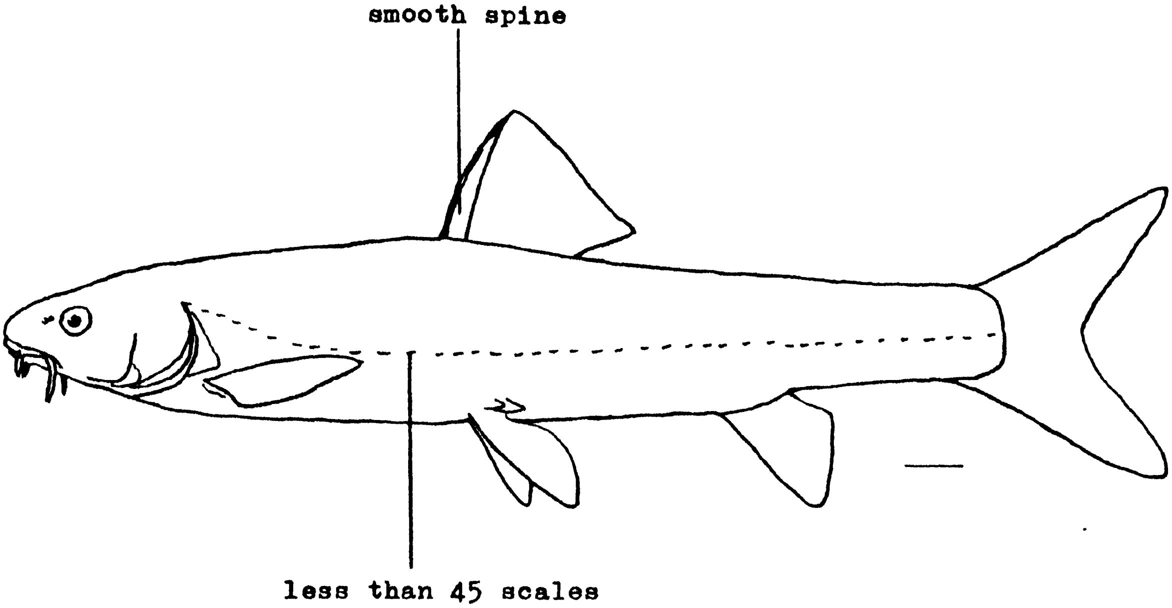
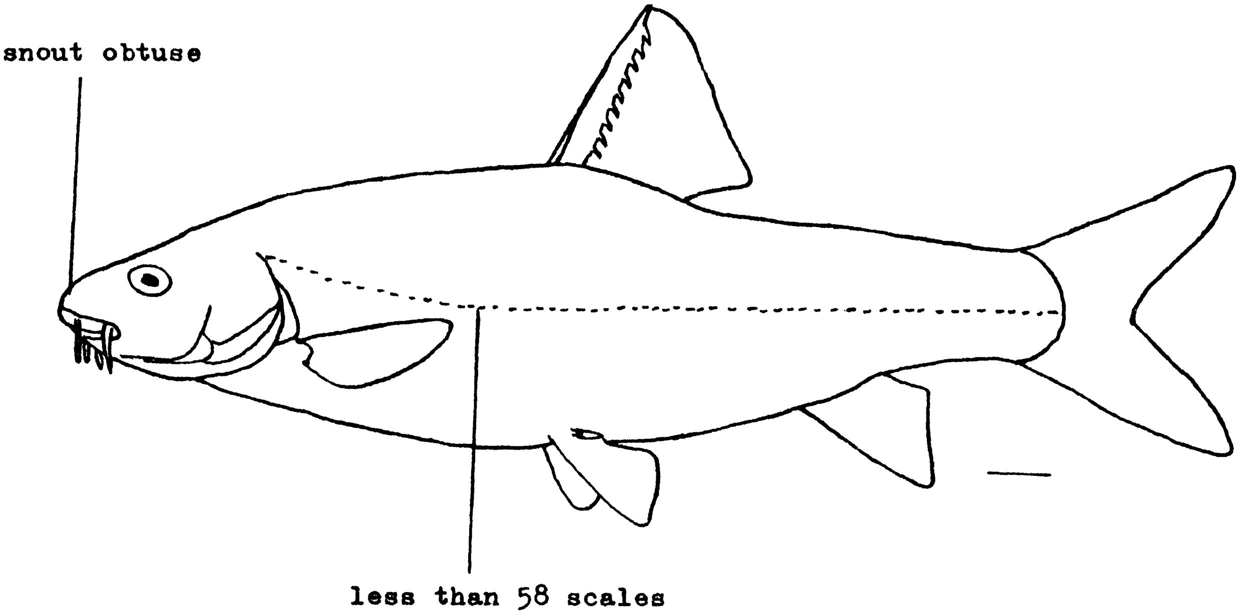


Figure 48. Barbus kersin



Dorsal fin with three simple rays, the third ray osseous and robust but not serrated; and 8 branched rays. Anal fin twice as high as broad, with 8 rays.

Color: Dark olive brown on back with lower sides and belly lighter with silvery reflections. An indistinct lateral band is usually present. Some individual scales darker giving a slightly mottled appearance, especially in young.

This fish was taken in the Euphrates and Tigris Rivers and Lake Khatuniyeh. It is reported to have reached lengths of nearly 2 meters, and a weight of 100 kilograms. It spawns in May or June on gravel beds. It is primarily a vegetation eater.

Barbus kersin Heckel

Body rather compressed and elevated; snout obtuse; mouth subinferior, lips moderately thick, the transverse fold of the lower jaw interrupted in the middle. Eyes of moderate size. Dorsal fin with three simple rays, the third very strong, osseous, and coarsely serrated, and with 8 branched rays. Anal fin with 3 simple rays and 5 branched rays, and is twice as high as long. Caudal fin deeply forked. Lateral line scales 55 to 56. There are seven rows of scales between the lateral line and the pelvic fin and 10 rows between the line and the dorsal fin.

Color: Generally light olivaceous above, belly and lower sides lighter.

This fish was taken from the Lake at Homs and from the Euphrates river and Lake Tiberias. It is an omnivorous feeder. It breeds in the early spring on gravel beds.

Barbus lacerta Heckel

The height of the body is contained 3 3/4 to 4 1/3 times in the length of the body without the caudal, the length of the head 3 2/3 to 4 times. The snout is long, the lips developed. The diameter of the eye is contained 2 to 2 1/4 times in the length of the snout, 1 2/3 to 1 3/4 times in the interorbital space, 5 to 5 1/2 times in the head length. There are two barbels on each side, the anterior equal or a little longer than the eye diameter, the posterior measures 1 1/5 to 1 1/3 of the latter. The pharyngeal teeth number 2, 3, 5 - 5, 3, 2. There are 56-62 scales in the lateral line, 7 or 8 rows between the lateral line and the pelvic fin, and 10 rows above the lateral line to the dorsal fin, and 22 scales around the caudal peduncle. The dorsal fin arises an equal distance from the tip of the snout to the origin of the caudal, or a little nearer the caudal, has a straight dorsal border, its third or sometimes its fourth simple ray is ossified, medium strong, with fine serrations on the posterior border. The longest ray of the dorsal fin is about 2/3 the head length. There are 8 branched rays in the dorsal. The anal, a little more than 2 times as high as wide, reaches almost to the caudal. The pectoral is slightly pointed, and is 3/4 to 4/5 the head length. The pelvic arises barely behind the origin of the dorsal. The caudal peduncle is 1 1/2 to 1 2/3 as long as high. The caudal fin is moderately forked, the lobes pointed, and much shorter than the head length. The anal fin has 3 simple rays and 5 branched rays.

Color: Body generally olive brown on the back, silverish white and yellowish on the sides and belly. There are brown, irregular spots on the back, dorsal and caudal.

This fish was taken from the Euphrates River. Nothing is known of its life history.

Figure 49. **Barbus lacerta**

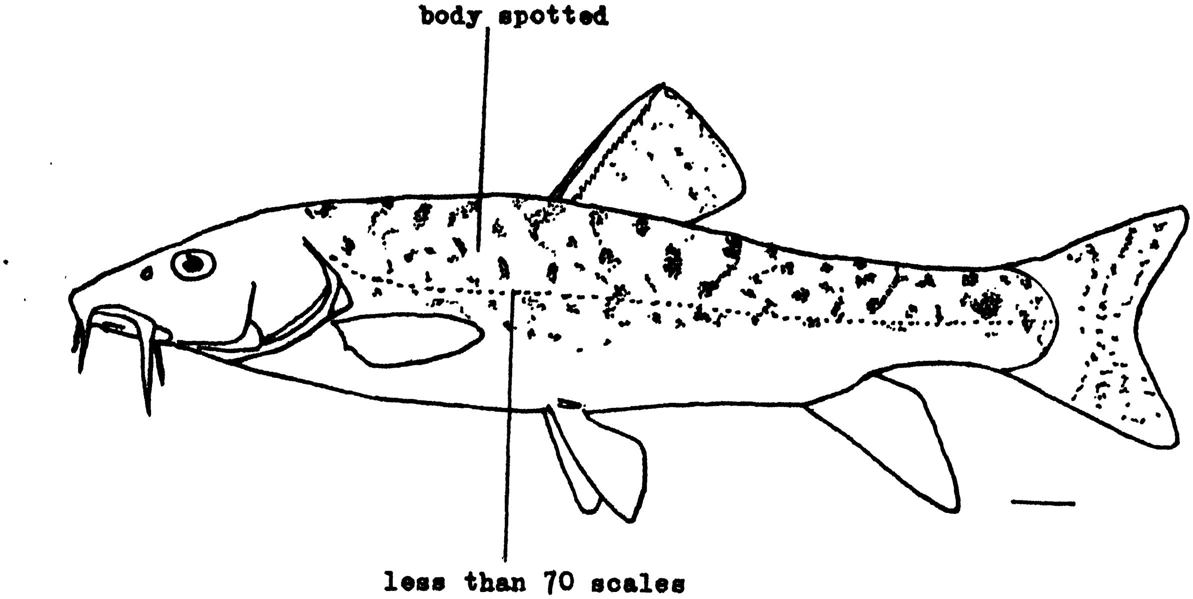
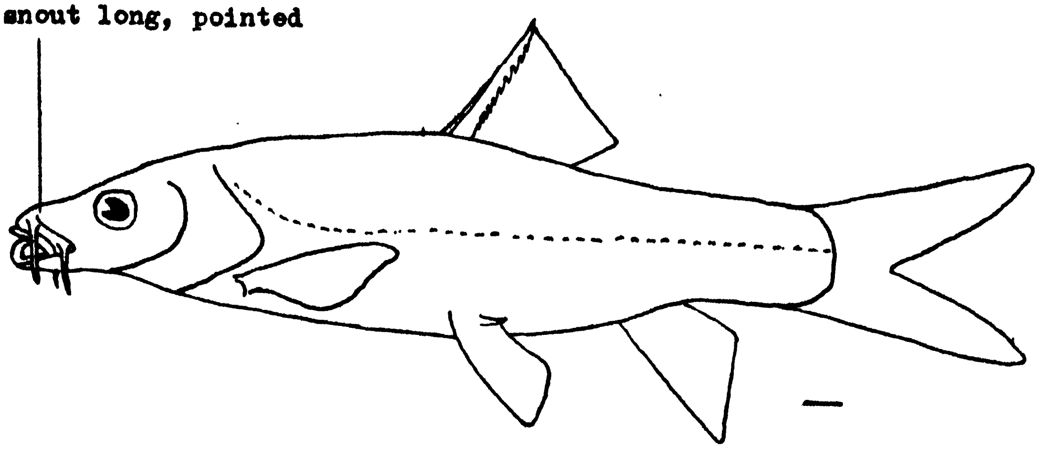


Figure 50. **Barbus longiceps**



Barbus longiceps Cuvier and Valenciennes

Body rather elongate, snout very long and pointed; lips thick with fold interrupted in the middle of lower jaw. Length of head contained 3 to 4 times in standard length. Eyes small. Dorsal fin with 3 simple and 8 branched rays, the third simple ray being ossified and strong and conspicuously serrate. Anal fin narrow and deep, with 3 simple and 6 branched rays. Lateral line scales 54-56, and 24 around caudal peduncle. Caudal fin deeply notched.

Color: Body light brownish with silvery reflections, back slightly darker.

This fish is taken in the Lakes Tiberias and Khatuniyeh.

Nothing is known of its life history.

Barbus lorteti Sauvage

Body elongate, the height being contained 4 1/2 in the total length; length of head 5 2/3 in the same dimension. Four barbels of the same length, a little longer than the diameter of the eye. Snout obtuse, 2 1/3 times as long as the eye, whose diameter is contained 6 1/2 times in the length of the head. The interorbital space 3 times as wide as the diameter of the orbit. Dorsal insertion equal distance from caudal and tip of the snout; third ray feeble, not serrate; three simple rays, 8 branched rays; dorsal nearly as high as long. Anal fin with 3 simple and 5 branched rays, nearly twice as high as long. Pelvics inserted under middle of the dorsal. Pectorals longer than the pelvics, separated from the pelvics by a space less than their length. Lateral line scales 60, with 12 rows between lateral line and dorsal fin, and 9 rows between lateral line and pelvic.

Color: Generally light brownish, with sides and belly slightly lighter in color.

This fish was reported from the Orontes River.

Nothing is known of its life history.

Figure 51. Barbus lorteti

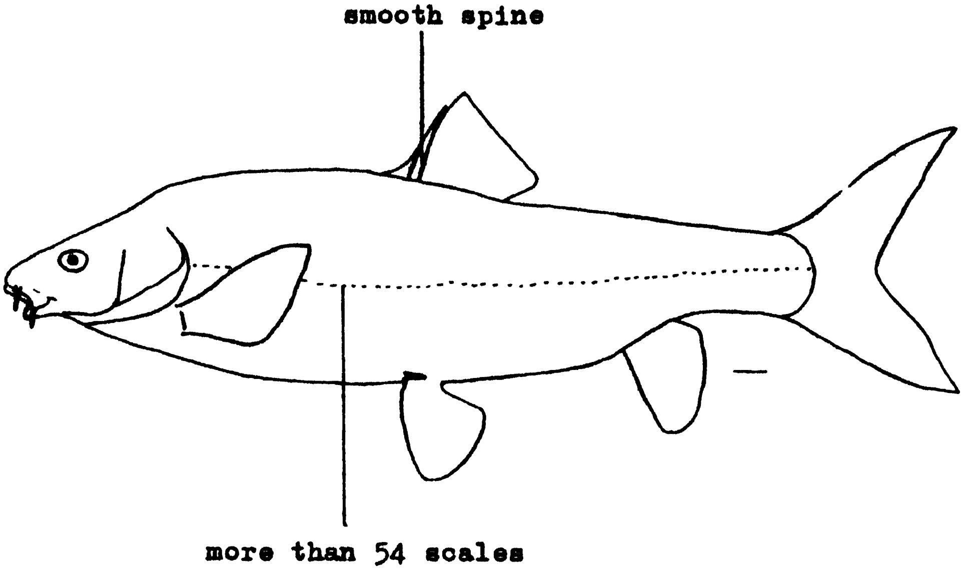
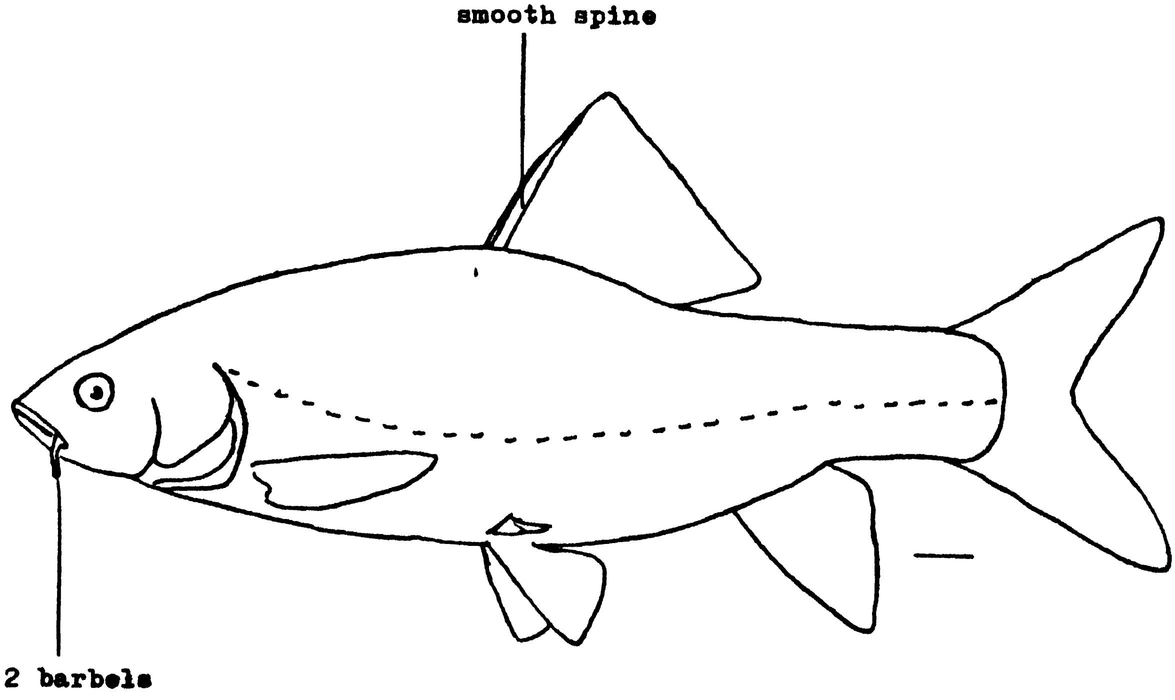


Figure 52. Barbus luteus



Barbus luteus Heckel

The height of the body is a little less than 1/3 the standard length; the length of the head about 2/9 of the standard length. The snout is obtuse, longer than the eye, which is small, about 1/6 of the head length. Mouth small, not extending backwards to the vertical from the front margin of the eye. Dorsal fin origin opposite to origin of pelvic, midway between snout tip and root of the caudal. Dorsal fin with 3 simple rays and 11 branched rays, the third ray of moderate length and strength and not serrate. Lateral line scales 28-30, with 5 rows between lateral line and dorsal fin and 4 rows between lateral line and pelvic. Anal fin with 3 simple rays and 6 branched rays.

Color: Body brownish with dark midstrips on back and dark lateral band. Belly silvery. Dark spot at base of caudal.

This fish was taken from the Orontes River, Lake Khatuniyeh, the Euphrates and Khabour Rivers.

This fish spawns in May or June. It is an herbivorous fish.

Barbus orontis Sauvage

Height of the body contained 4 3/4 times in the standard length, equal to the head length. Head a little elevated to the level of the dorsal, forehead a little declined. Four barbels, wide and thick, of the same length, twice as long as the diameter of the eye; mouth a little inferior, lips thick; snout compressed, about three times as long as the eye. Eye contained 7 1/2 times in the head length. Interorbital space nearly flat, 3 times as wide as eye diameter. Dorsal fin insertion nearer the caudal peduncle than the tip of the snout; third ray feeble, not serrate; fin as long as high; three simple rays, 8 branched rays. Anal fin higher than dorsal, three simple rays, 6 branched rays. Caudal fin strongly notched, contained 6 times in the standard length. Pelvic insertion under the origin of the dorsal. Pectoral longer than the pelvics, separated by a space almost equal to their length from the pelvics. Lateral line scales 50, 10 rows between dorsal and lateral line, 10 rows between lateral line and pelvics.

Color: Generally light brownish, with darker on head and back.

This fish is reported from the Orontes River. Nothing is known of its life history.

Figure 53. Barbus orontis

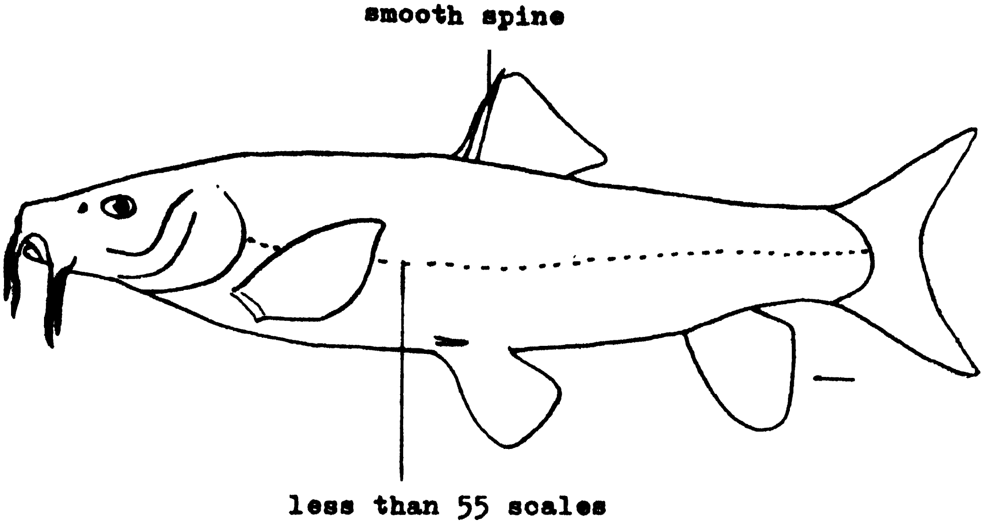
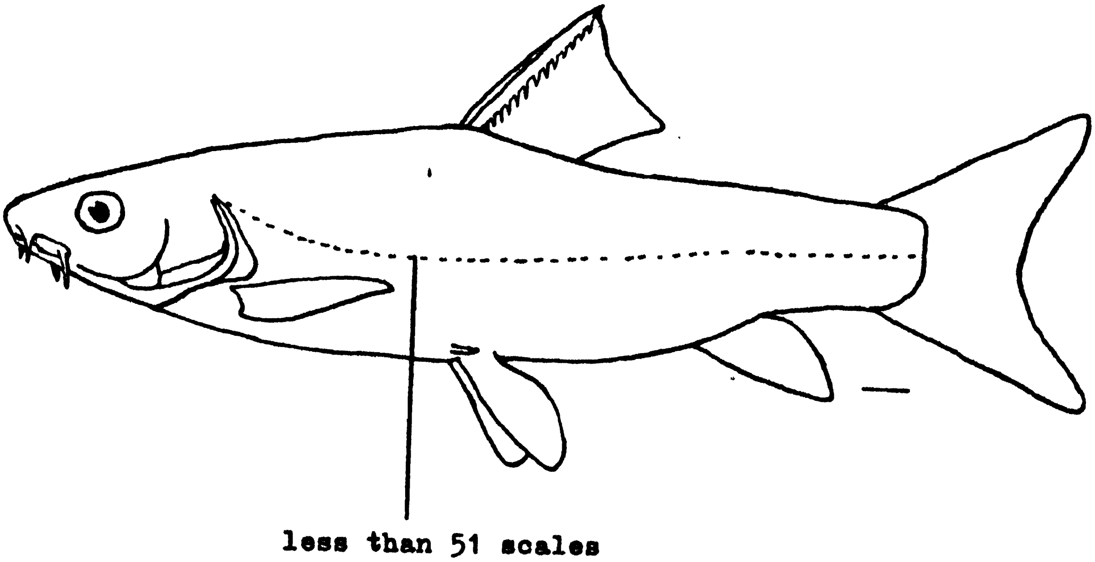


Figure 54. Barbus pectoralis



Barbus pectoralis Heckel

Body oblong, rather compressed. Height of body contained 3 2/3 times in the standard length; head length contained about 4 times. The snout is rounded, its length equal to the interorbital space. The diameter of the eye is contained 4 times in the head length, 1½ times in the interorbital space. The mouth is sub-inferior, the lips thin, the lower lip fully separated underneath. There are two barbels on each side, the anterior a little shorter, the posterior equalling the eye diameter. There are 44-50 scales in the lateral line, 7 rows between the lateral line and the pelvic fin. The scales on the belly are small in front. The dorsal fin possesses 3 simple rays and 8 branched rays. The third simple ray is about 3/5 the head length, and is strongly toothed behind. The origin of the dorsal fin is equal distant between the snout and the caudal origin. The anal fin has three simple rays and 6 branched rays, and does not reach the caudal. The pectoral fin has 2/3 to 3/4 the length of the head and does not reach the pelvic. The pelvic origin is under the origin of the dorsal and does not reach the anal. The caudal peduncle is 1 ¼ times to 1 1/3 times as long as high. The caudal is forked.

Color: Generally olivaceous on the back, sides silverish and the belly whitish. Scale borders outlined with small dark dots.

This fish was taken from the Orontes River and its tributaries. Nothing is known of its life history.

Barbus rajanorum Heckel

Body slender, its height is contained four times in the standard length, the length of the head 4 ½ times. The snout is moderately produced, rounded, and equals the interorbital space. The eye diameter is contained six times in the head length, 2 ½ times in the interorbital space. The mouth is inferior, the lips thick, the inferior fully interrupted beneath. There are two pairs of barbels, they are equal in length, and nearly equal to the eye diameter. The lateral line count is from 57 to 65. There are 12 rows of scales between the lateral line and the dorsal fin and 7 rows between the lateral line and the pelvic, and 24 scales around the caudal peduncle. The dorsal fin is a little less high than long, possessing three simple rays and 8 branched rays. The third simple ray is very strong and very finely serrate behind, and is less than 2/3 the head length. The anal fin has three simple rays and 6 branched rays, and reaches nearly to the caudal. The pectoral fin is slightly rounded, about 4/5 the head length, and does not reach the pelvic. The pelvic begins under the second branched ray of the dorsal and does not reach the anus. The caudal fin is forked. The caudal peduncle is 1 1/3 times as long as high.

Color: The general color is silvery grey, the belly whitish.

This fish was reported from the Aleppo region. Nothing is known of its life history.

Barbus scincus Heckel

Body elongate, subcylindrical; snout moderately produced, with the upper profile convex. The mouth is inferior, lips thick. The head length is 2/9 the standard length. The dorsal fin is composed of three simple rays, and 8 branched rays, the third ray being rather feeble, and finely

Figure 55. Barbus rajanorum

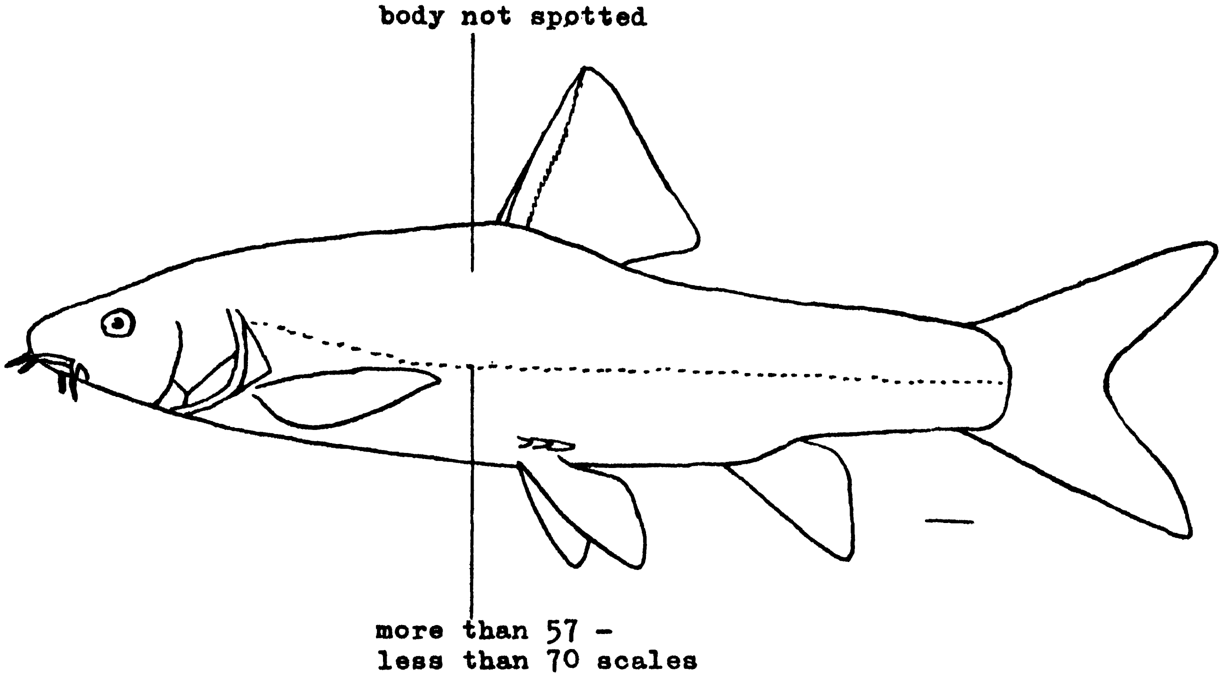
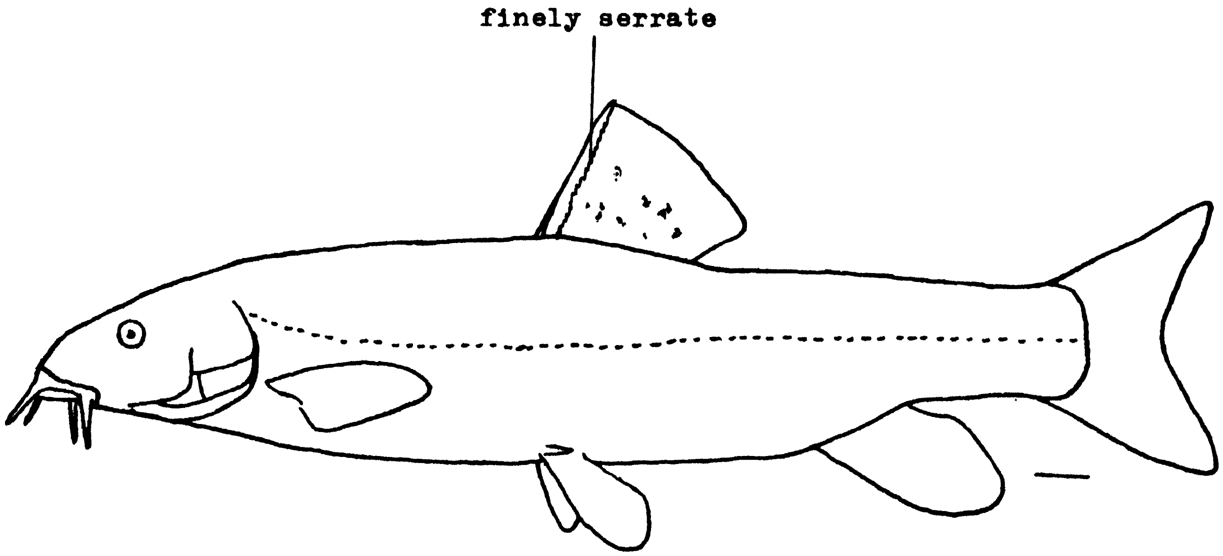


Figure 56. Barbus scincus



serrated. The anal fin is 2/3 as broad as high, and composed of three simple rays and 5 branched rays. The caudal fin is moderately notched. The lateral line scale count is 55-56, with 7 scale rows between the lateral line and the base of the pelvic, and 10 rows between the dorsal fin and the lateral line.

Color: Generally light brownish with body covered with dark clouded spots.

This fish was reported from the River Kueik near Aleppo. Nothing is known of its life history.

Barbus sharpeyi Gunther

The height of the body is rather more than one-fourth the standard length, the length of the head 2/9. The snout is rather short and obtuse. There are no barbels. The dorsal fin contains three simple rays and 8 branched rays, the third simple ray is rather strong, and not serrated behind, and nearly as long as the head without the snout. The lateral line scales are 30-31, and there are 2 or 3 rows of scales between the lateral line and the pelvic, and 4 rows between the lateral line and the dorsal fin. Pelvic fin origin directly opposite origin of dorsal. Caudal fin deeply forked.

Color: Generally light brownish, with sides and belly lighter.

This fish is found in the Euphrates River. It is a vegetable feeder and prefers the quieter water, especially marshy areas. It deposits its eggs on the vegetation in about 0.75 meters depth. It spawns in May.

Barbus subquincuniatus Gunther

Body elongate, the height equal to the length of the head, which is contained 5 1/3 times in the standard length. Four barbels, thick and the same length; lips thick, the inferior hanging. Snout elongate, 3 1/2 times as long as the eye, which is situated in the middle of the length of the head; interorbital space three times as wide as diameter of the eye. Dorsal insertion a little nearer the caudal peduncle than the tip of the snout. Dorsal fin composed of three simple rays and 8 branched rays, the third ray being very strong and finely serrate posteriorly. Anal fin same height as the dorsal, and twice as high as long, composed of three simple rays and 5

Figure 57. Barbus sharpeyi

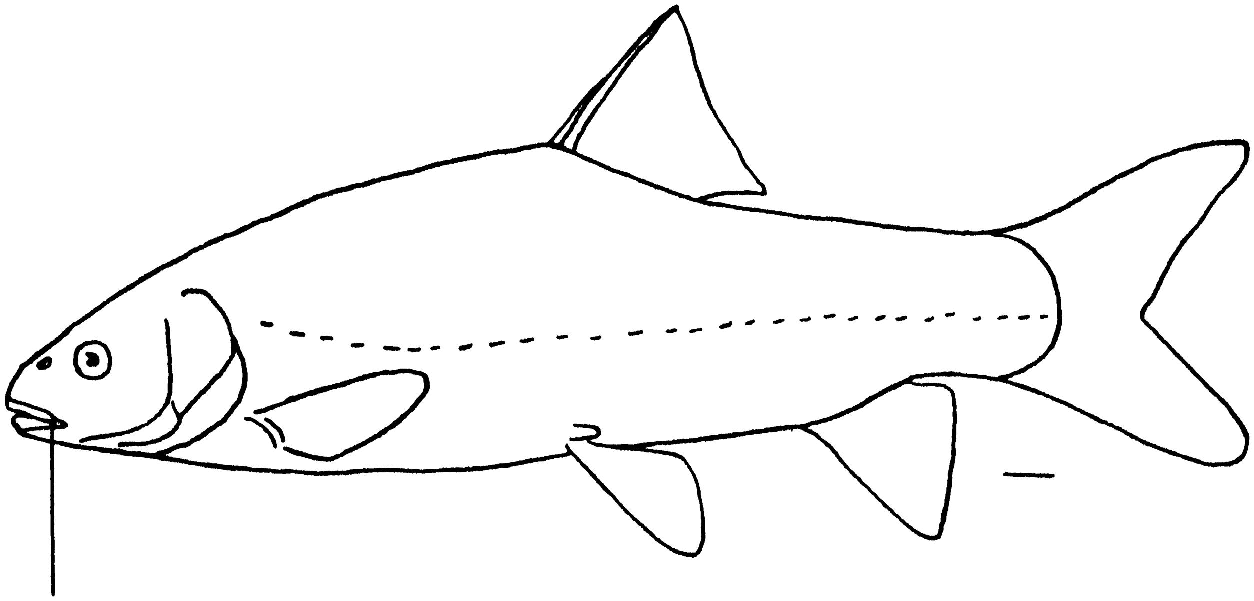
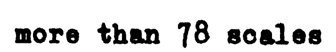


Figure 58. Barbus subquincuniatus



branched rays. Pelvic insertion a little in front of the middle of the length of the dorsal. Pectorals a little longer than the ventrals. Lateral line scale count 84.

Color: Generally brownish yellow, with numerous irregular black spots disposed quincunx; these spots similarly on all the fins. Head of a unifrom brown color.

This fish was taken in the Euphrates River.

Nothing is known of its life history.

Barbus xanthopterus (Heckel)

Body elongate, compressed, elevated at the level of the dorsal; height contained 4 2/3 in total length, head 4 3/4 times. Four barbels, thick, the superiors a little shorter than the inferiors. Lips thick, divided and presenting two lobules median. Snout 3 1/2 times as long as the eye, whose diameter is contained a little more than 8 times in the length of the head; interorbital spaces 3 times as wide as the diameter of the eye. Dorsal insertion nearer the caudal peduncle than the tip of the snout. Dorsal fin composed of three simple rays and 8 branched rays, the third simple ray very strong, having strong teeth, and almost 2/3 of the height of the body at the corresponding point. Anal fin of same height as the dorsal, 1 ½ times as high as long, and composed of three simple rays and 5 branched rays. Pelvic insertion under the origin of the dorsal. Pectorals a little longer than the pelvics. Caudal fin notched. Lateral line count 58.

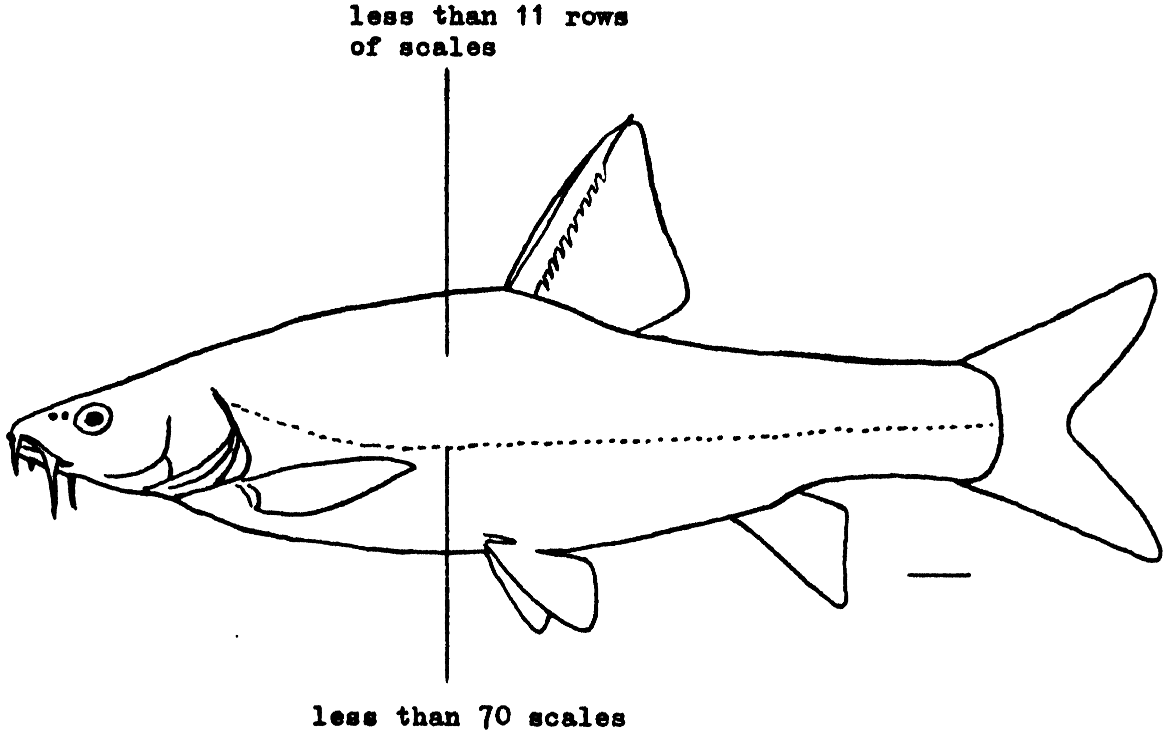
Color: Generally brownish, with sides and belly lighter.

This fish is reported from the Euphrates. It feeds mainly on plants and plankton. It spawns on fine gravel beds, and digs a small nest in the gravel, depositing the eggs in this nest. The water is usually from 1/3 to 1 meter in depth. Spawning is usually in May.

Genus Barilius Ham. Buchanan

Scales small, or moderate. Lateral line running along lower part of tail. Abdomen not compressed into an edge. Dorsal fin short, with less than 9 branched rays, inserted distinctly behind the root of the pelvics. Anal fin elongate, 10 or more rays. Mouth anterior. Barbels four, two or none. Maxillary reaches to or below, but not behind orbit. Suborbitals

Figure 59. Barbus xanthopterus



generally broad, the third never narrower than the soft portion of the cheek, and partly situated below the orbit. Gill rakers very short; pseudobranchiae present. Pharyngeal teeth 1, 3 or 4, 5-5, 3-4, 2-1, uncinate.

This genus is represented by one species in Syria.

Barilius mesopotamicus Berg

Body elongate; mouth terminal, snout end corresponds with lower edge of pupil; maxillary scarcely reaches to vertical line through center of eye; two thin maxillary barbels, approximately equal to eye diameter; lateral line complete or nearly so, following closely the ventral outline even on the caudal peduncle; one row of scales between lateral line and pelvic; lateral line scales 46-50; pharyngeal teeth in three rows 1, 4, 5-5, 4, 1; gill rakers 8 on first arch, short; dorsal fin origin before origin of anal and behind inner insertion of pelvic; pectoral fin reaches pelvics; pelvic fin reaches anus; dorsal fin rays II, 8; anal fin II, 13; eye large, 1/3 head length and equal to interorbital width.

Color: body silvery with upper 1/8 slightly darker; back with dark median stripe; upper side with 8 or 9 round dark spots.

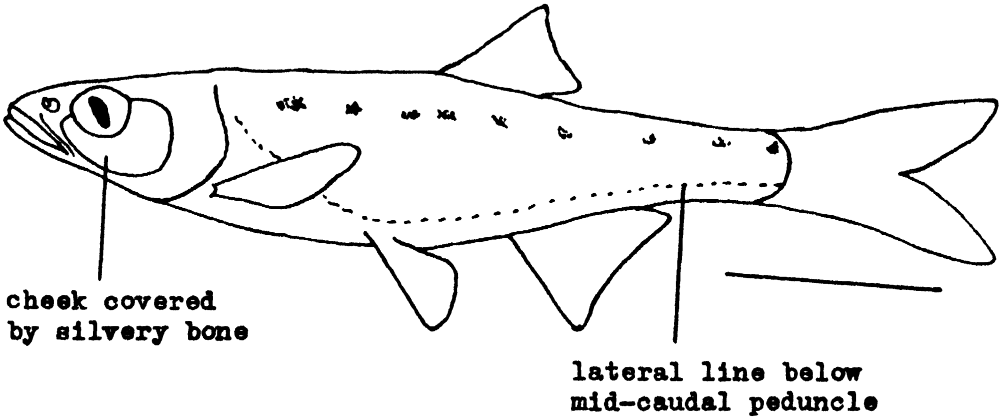
This fish was taken from the Euphrates River. Nothing is known of its life history.

Genus Chondrostoma Agassiz

Body more or less compressed, covered with medium scales. Mouth inferior, without barbels, a transverse slit and curved; lips hard and sharp, covered with a corneous layer. Suborbitals small. Cheeks naked. Pharyngeal teeth in one row, 5 to 7-7 to 5, pointed, flat and obliquely crowned. Lateral line complete, closer to belly than the back, but medial on the caudal peduncle. Dorsal fin short without ossified ray, composed of 3 simple rays and 8-10 branched. Origin is above the pelvics. Anal fin rather elongate, with 3 simple and 8-12 branched rays. A scaled appendage at base of the pelvic. Peritoneum black.

One species represents this genus in Syria.

Figure 60. Barilius mesopotamicus



Chondrostoma regius Heckel

The height of the body is contained 4 to 4 3/4 times in the standard length, the length of the head 4 ½ to 4 4/5. The diameter of the eye is contained 4 to 5 times in the head length, 1 1/4 to 1 1/3 in the snout length, and 1 1/3 to 1 ½ times in the interorbital space. The snout is stout, rounded, and overhangs greatly the mouth. The mouth is transverse, a little curved, and extends nearly from one side of the head to the other. The lips are thick. The pharyngeal teeth usually 7-7, sometimes 7-6 or 6-6. The lateral line scale count is 64-68 scales, with 5 rows between the lateral line and the pelvic, and 20-22 around the caudal peduncle. The dorsal origin is equal distant from the tip of the snout to the origin of the caudal or a little nearer the latter; its superior border is straight; its rays are composed of three simple rays and 9 branched rays. The longest rays of the dorsal are 3/4 to 5/6 the height of the head. The anal fin is composed of three simple rays and 10-11 branched rays, its anterior rays nearly as long as the dorsal fin. The pectoral fin is rounded and nearly reaches the pelvics, and are about 2/3 to 4/5 the length of the head. The pelvic fin arises under the origin of the dorsal or a little farther forward. The caudal peduncle is 1 3/5 to 2 times as long as high. The caudal is forked and the lobes pointed.

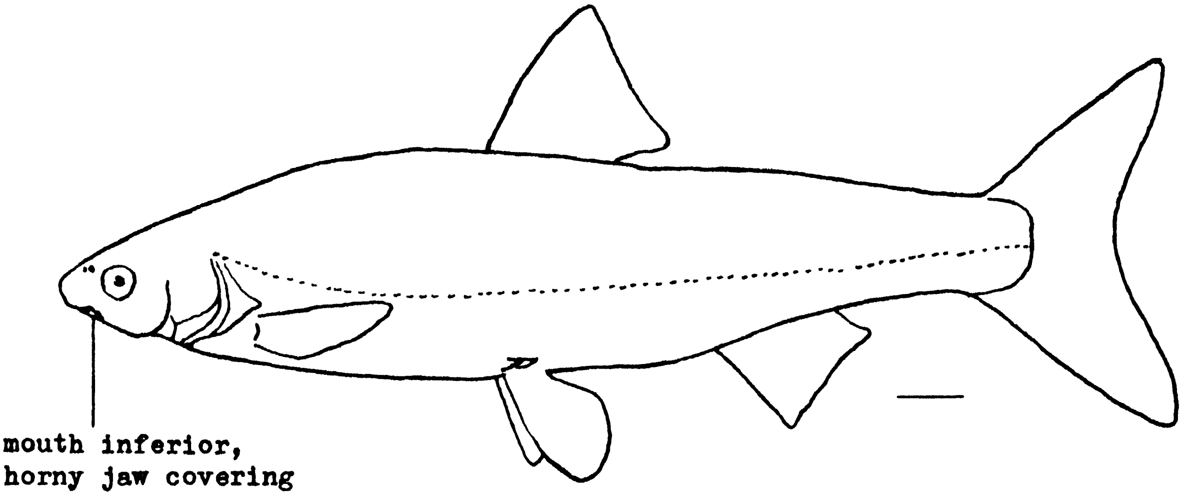
Color: Olive brown on the back with bluish reflections, silver white on the sides and belly. The dorsal and caudal fins are greyish, the other fins clear.

This fish was taken from the Orontes, Queiq, Euphrates and the Khabour Rivers. It attains a length up to about 40 centimeters and weight up to one kilogram. It is an omnivorous feeder, feeding on eggs and fry of other fish as well as on insect larvae and other foods. It spawns in the spring, probably in May or June.

Genus Cyprinion Heckel

Body moderately elongate, somewhat compressed. Snout thick, rather prominent. Mouth inferior, lower jaw with a sharp, horny edge, without lip.

Figure 61. Chondrostoma regius



Scales of moderate size, lateral line running along middle of caudal peduncle. Dorsal fin with a strong, serrated osseous ray, and numerous branched rays. Anal fin short. Two barbels. Pharyngeal teeth 2, 3, 4-4, 3, 2, compressed.

Key to Species of *Cyprinion*

1 a. Origin of dorsal fin above origin of pelvics;
mouth small, with large lateral lobes...........*C. kais*

1 b. Origin of dorsal fin in front of origin of
pelvic fins; mouth large, no lateral lobes......*C. macrostomus*

Cyprinion kais Heckel

The height of the body is one-third or somewhat less than one-third of the standard length. The origin of the dorsal is above that of the pelvics. The dorsal fin consists of 4 simple rays and 13 or 14 branched rays. The osseous dorsal ray is of moderate length and strength. The anal fin is composed of 8 or 9 rays. The lateral line contains 42 scales.

Color: Uniformly silverish.

This fish is reported from the Tigris, Euphrates and Khabour Rivers, and from the region of Aleppo. Nothing is known of its life history.

Cyprinion macrostomus (Heckel)

The height of the body is one-third to 2/7 of the standard length. The origin of the dorsal fin is somewhat in advance of the insertion of the pelvic. The dorsal fin contains four simple rays and 14 branched rays, with the osseous dorsal ray of moderate length and strength. The anal fin contains 9 rays. The lateral line contains 42 scales. The mouth is large, straight across and inferior, with no lateral lobes.

Color: Uniformly whitish.

This fish was taken from the Tigris, Euphrates, and Khabour Rivers. Nothing is known of its life history.

Genus *Cyprinus* Linnaeus

Body robust, compressed; mouth moderate, anterior, and with four

Figure 62. Cyprinion kais

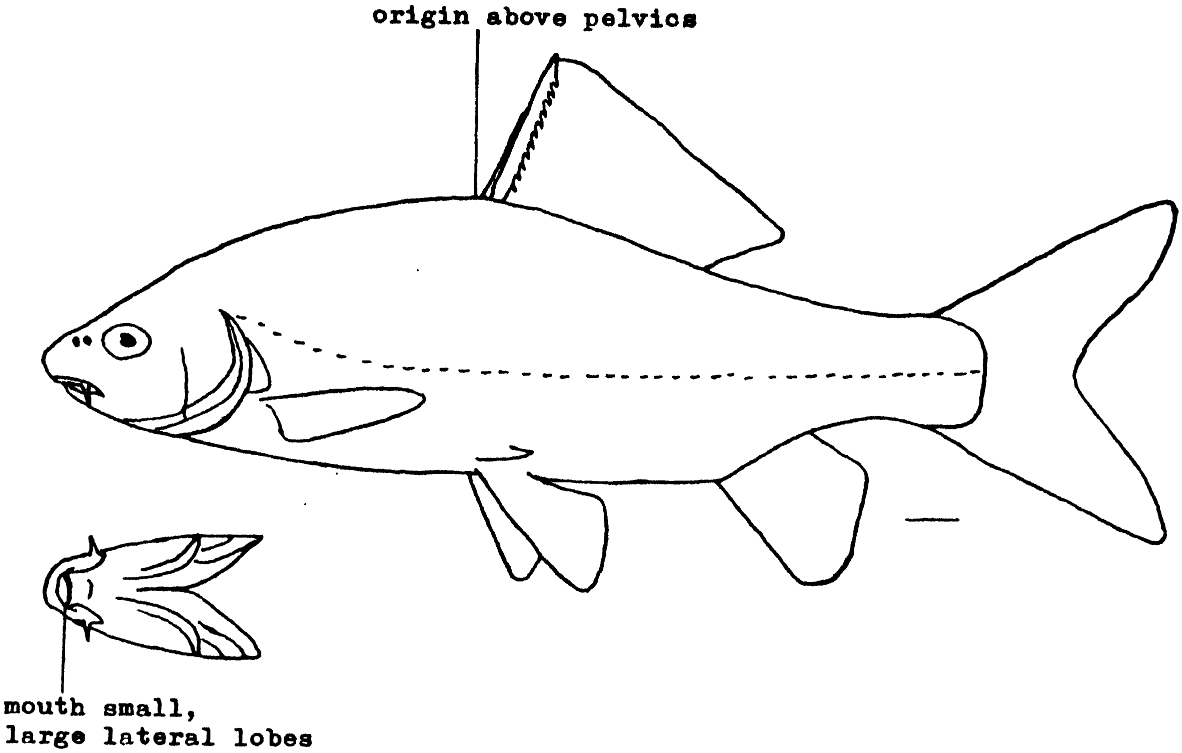
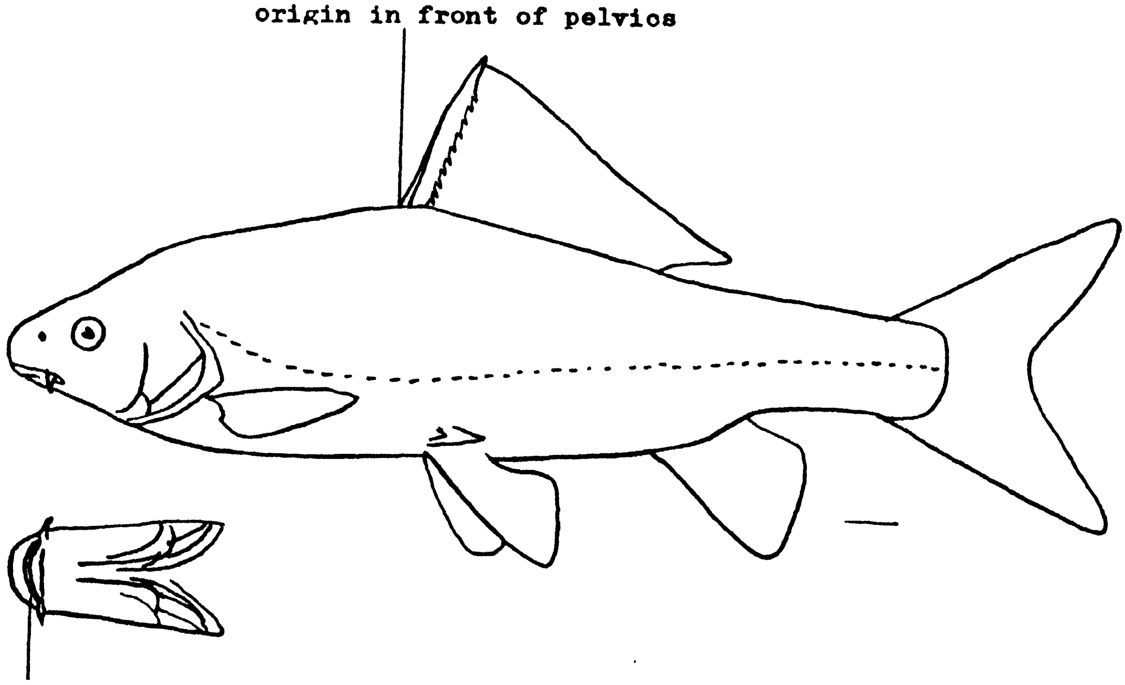


Figure 63. Cyrpinion macrostomus



barbels; snout blunt, rounded. Pharyngeal teeth molar, broad, truncate, 1, 1, 3-3, 1, 1. Scales large, Lateral line complete. Dorsal fin long, with stout spine, toothed behind. Anal fin short and with spine.

This genus is represented by one species.

Cyprinus carpio Linnaeus

Body robust, compressed, back considerably elevated; head conical, tapering rapidly from above to the tip of the pointed snout. Nose bluntly pointed. Mouth rather small, anterior, oblique, the maxillary not reaching past anterior nostril. Two pairs of maxillary barbels. Pharyngeal teeth broad and truncate with molar surface; in three rows, 1, 1, 3-3, 1, 1. Intestine longer than body. Peritoneum grey, often speckled. Dorsal and anal fins with strong spine, toothed behind. Dorsal fin with three or four simple rays and 17-22 soft rays; anal fin with 2 or 3 simple rays and 5 branched rays. Scales are large, 35-38 in lateral line, and 5 or 6 rows above lateral line and 5 or 6 rows between lateral line and pelvic fin.

Color: Olivaceous, with upper parts bluish to dusky; lower parts of sides and belly more or less yellowish.

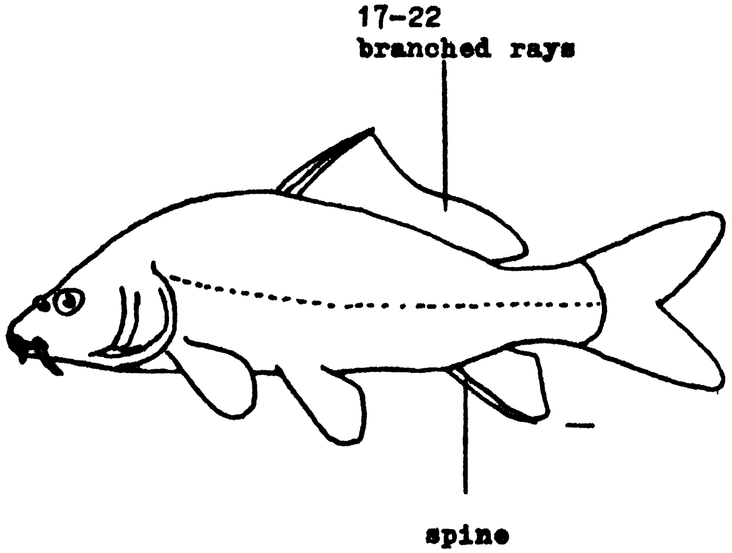
This fish is found in Lake Tiberias and in isolated ponds in the vicinity of Damascus. It is expected that it will soon be propagated in artificial ponds in the el Ghab area.

This fish is found in Lake Tiberias and in isolated ponds in the vicinity of Damascus. It is expected that it will soon be propagated in artificial ponds in the el Ghab area.

There are three kinds of carp: fully scaled, partially scaled and scaleless. A number of varieties based on growth form are also to be found, but they are basically the carp.

Carp prefer moderately warm water, not too deep, and with plenty of aquatic vegetation. It will live, however, in almost any situation, thriving in waters of high turbidity and contamination, as well as in clear water. Under favorable conditions, carp may attain a length of nearly one

Figure 64. *Cyprimus carpio*



meter and a weight of 40 kilograms. It spawns in the spring when the water temperature reaches 20° C. The eggs are scattered near the shore where the adhesive eggs stick to the vegetation and roots of the aquatic plants and debris. The eggs are quite small, about 1 to 1 ½ millimeter in diameter, a two kilogram female may lay as many as 500,000 eggs.

Carp are omnivorous feeders, taking principally insect larvae and nymphs, crustaceans, small mollusks, other small aquatic plants and animals, and vegetable matter and debris. It often roots up vegetation while feeding.

Genus *Garra* Ham. Buchanan

Scales of moderate size. Dorsal fin without osseous rays, with not more than nine branched rays, commencing somewhat in advance of the pelvis. Snout obtusely rounded, more or less depressed, projecting beyond the mouth, more or less tubercular. Mouth inferior, transverse, crescent-shaped; lips broad, continuous, with an inner sharp edge of the jaws covered with horny substance on the lower jaw; upper lip more or less distinctly fringed; lower lip modified into a suctorial disk, with free anterior and posterior margins. Barbels two or four; if two, the upper are absent. Anal scales not enlarged; lateral line running along the middle of the side of the tail. Anal fin short. Pectoral fins horizontal. Pharyngeal teeth 2, 4, 5-5, 4, 2.

There are three species of this genus represented in Syria.

Key to the Species of *Garra*

1 a. One pair of barbels..............................*G. variabilis*
1 b. Two pairs of barbels
  2 a. Less than 12 gill rakers on lower arch.......*G. lamta*
  2 b. More than 11 gill rakers on lower arch.......*G. rufus*

Garra lamta (Buchanan)

Body somewhat elongate, snout obtusely rounded. Mouth inferior with lower lip modified into a suctorial disk. Disk very slightly fringed if at all. Four barbels present, anterior barbels about equal to eye diameter. Dorsal fin with 2 simple rays and 9 branched rays. Dorsal fin origin over insertion of pelvic or but slightly behind. Anal fin with 7 rays. Pectoral

Figure 65. *Garra lamta*

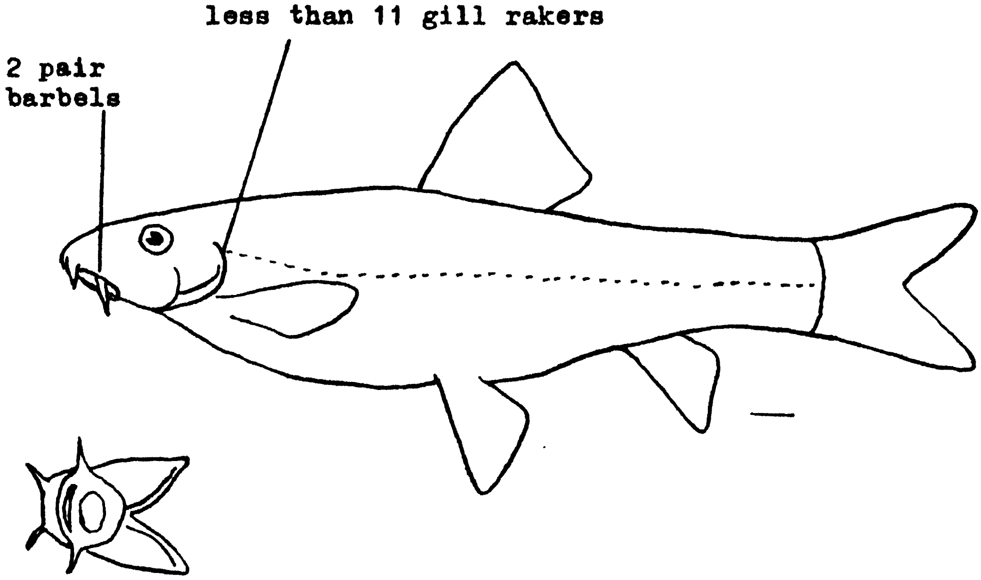
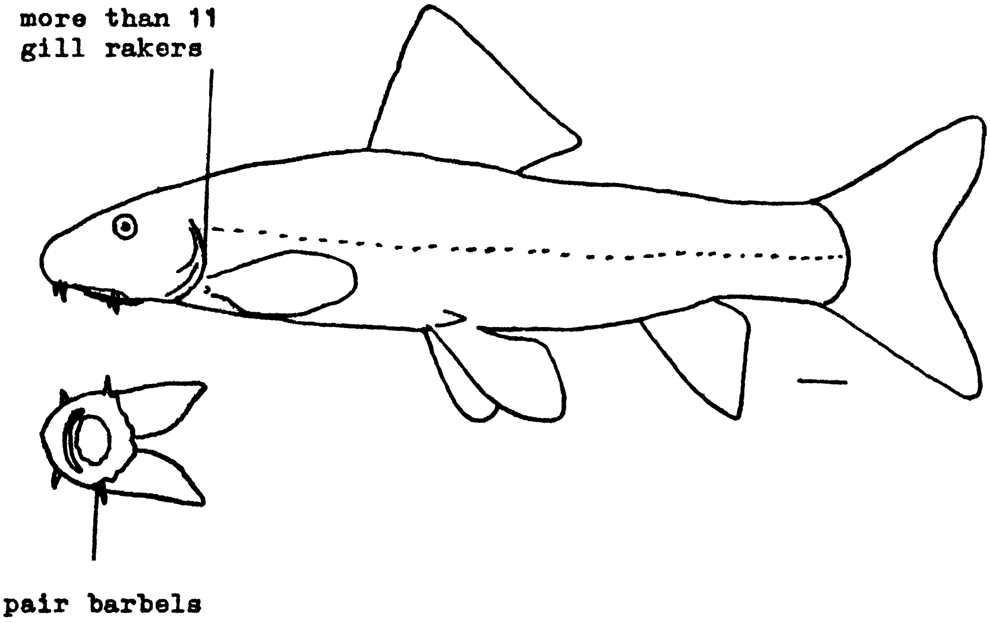


Figure 66. *Garra rufus*



fin about as long as head or slightly less. Lateral line scales 33-36. Gill rakers 7-10.

Color: Dark olive-brown to blackish, belly lighter. Black spot behind middle of upper end of gill opening. Sometimes a dark lateral band terminating in a spot at base of caudal fin.

Nothing is known of its life history.

Garra rufus (Heckel)

Body elongate, snout bluntly obtuse, mouth inferior, lower lip modified into suctorial disk which is rather large, reaching behind the posterior border of the eye, and is fringed. Dorsal fin with 2 simple and 8 branched rays. Origin of dorsal fin well in front of insertion of the pelvics. Lateral line scales 34-36. Gill rakers on lower gill arch 12-15. Four barbels, shorter thán eye.

Color: Body generally brownish olive to blackish, belly lighter. Sides mottled with blackish. Pectoral and pelvic and anal fins in breeding males orange red. Black spot behind gill opening, may be greenish blue in life. Caudal orangish in breeding specimens. Tail tipped with black. Black spot at base of caudal.

This fish was taken in the Orontes drainage and from the Afrin River, Muzerib, the Euphrates, Khabour Rivers, and the Khebir and Snouber Rivers of the Mediterranean drainage.

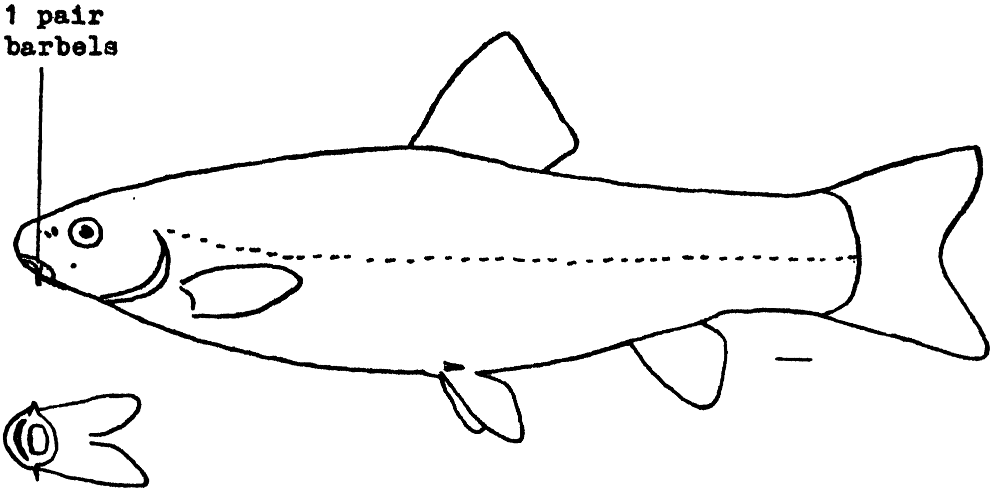
Nothing is known of its life history.

Garra variabilis (Heckel)

Body elongate, snout bluntly obtuse. Mouth inferior, lower lip modified into small suctorial disk, slightly if at all fringed, and scarcely reaching anterior border of eye. Two barbels present at angle of mouth, smaller than eye diameter. Dorsal fin with 2 simple and 7 branched rays. Origin of dorsal in front of insertion of pelvics. Anal fin with 7 rays. Pectoral fins shorter than head terminating at least length of it from insertion of pelvics. Lateral line scales 34-40.

Color: Body mottled dark olivaceous brown, belly lighter.

Figure 67. *Garra variabilis*



A tendency toward a dark lateral band, especially in young, and on caudal peduncle. A black spot at base of caudal.

This fish was taken from the Oronte's drainage, the Queiq and Tigris Rivers.

Genus Leuciscus Klein

Body more or less compressed, covered with large or medium scales. Mouth medium to large, without enlarged lips, lower jaw not trenchant, no barbels. Dorsal fin short, without ossified rays, composed of 2 or 3 simple rays and 7 to 9 branched rays, with insertion opposite, rarely behind, insertion of pelvics. Anal fin short, with 9 to 13 rays. Pseudobranchiae present. Pharyngeal teeth in two rows, 2, 5-5, 2, long and hooked. Intestinal tract short, with only few convolutions. A scaled appendage at base of pelvic fin.

Three species of this genus are likely to be found in Syria.

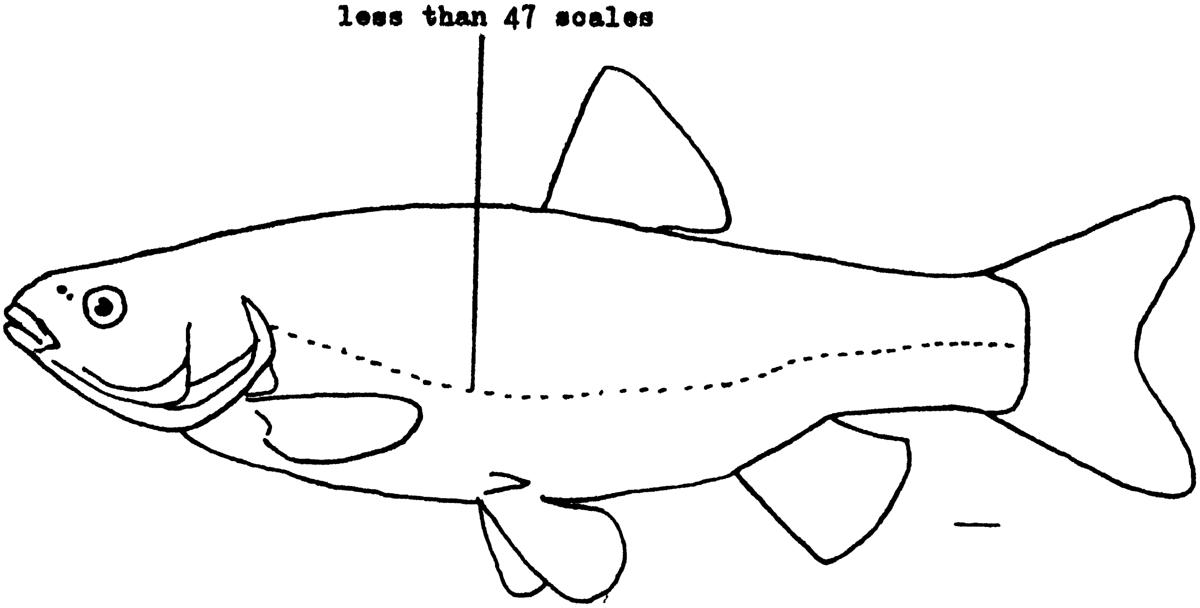
Key to the Species of Leuciscus

1 a. Scales in the lateral line less than 47..........................L. cephalus orientalis
1 b. Scales in lateral line more than 46
  2 a. Origin of dorsal opposite innermost of pelvic; origin of anal in back of last dorsal ray; 7 rows of scales above lateral line...................L. lepidus
  2 b. Origin of dorsal in back of innermost root of pelvic; origin of anal below last dorsal ray; 10 rows of scales above lateral line.............L. spurius

Leuciscus cephalus orientalis Heckel

Body somewhat compressed, the height a little less than four times in the standard length. The width of the interorbital space is about 2/5 the

Figure 68. Leuciscus cephalus orientalis



head length. Eye rather small. Cleft of mouth slightly oblique, of moderate width, not extending below the front margin of the eye. Jaws nearly equal in front. Origin of dorsal fin opposite to the root of the inner pelvic rays. Dorsal fin with 3 simple and 8 branched rays. Length of pelvic fin more than half head length. Anal fin with 3 simple rays and 7 branched rays. Lateral line scales 40-41.

Color: Body generally silvery in color, with back somewhat darkened. Scales with base darker.

This fish was taken from the Orontes, Euphrates, Khabour and Tigris drainages. It may attain a length up to 60 centimeters and a weight of 6 kilograms. It feeds on aquatic insects and their larvae, other small aquatic animals. It spawns in late spring. A female from 20 to 40 centimeters in length will lay from 20 to 50,000 eggs. The males during spawning season usually develop horny tubercles on the snout.

Leuciscus lepidus (Heckel)

Body somewhat compressed, the height contained 4 ¼ times in the standard length. Interorbital space broad, its width being two-fifths of the head length. The eye is rather small. The cleft of the mouth is oblique, of moderate width, the lower jaw slightly projecting beyond the upper. Origin of dorsal fin opposite to the insertion of the pelvic inner rays. Dorsal fin with 3 simple rays and 8 branched rays, anal fin with 3 simple and 9 or 10 branched rays. The lateral line count is 48 or 49.

Color: Generally silvery, with back slightly darker.

This fish was taken from the Tigris River. Its life history is quite similar to that of L. c. orientalis.

Leuciscus spurius (Heckel)

Body somewhat compressed, the height of the body is about two-ninths of the standard length. The diameter of the eye more than one-half the width of the interorbital space, and two-ninths of the head length. Mouth moderate width, not extending to the vertical from the front margin

Figure 69. Leuciscus lepidus

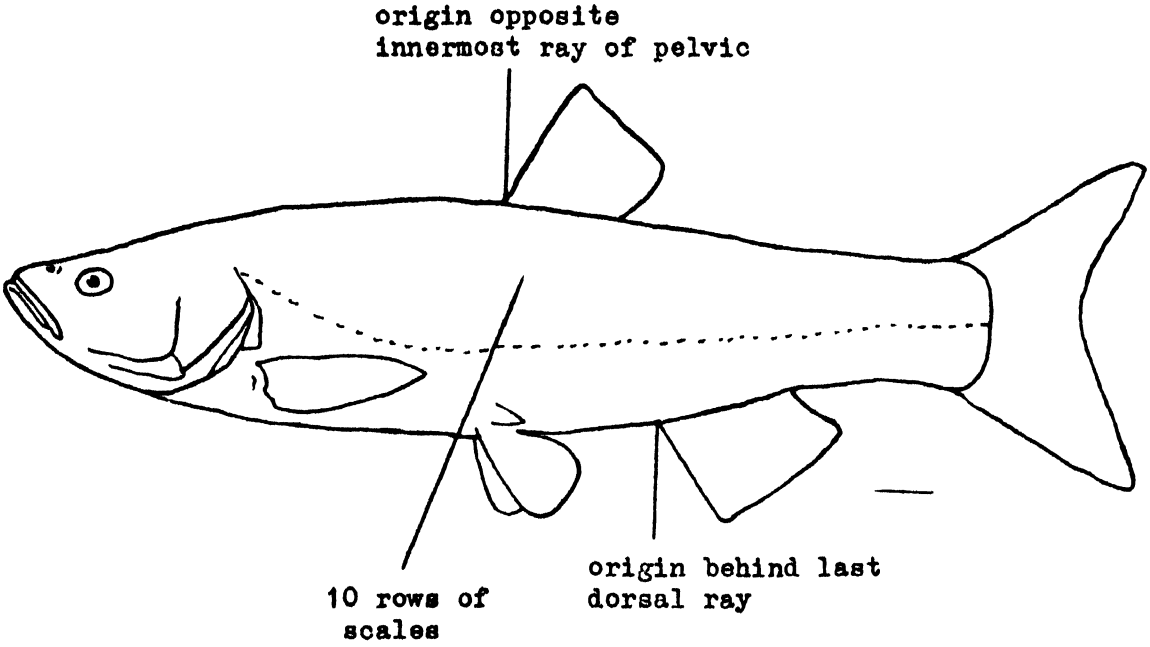
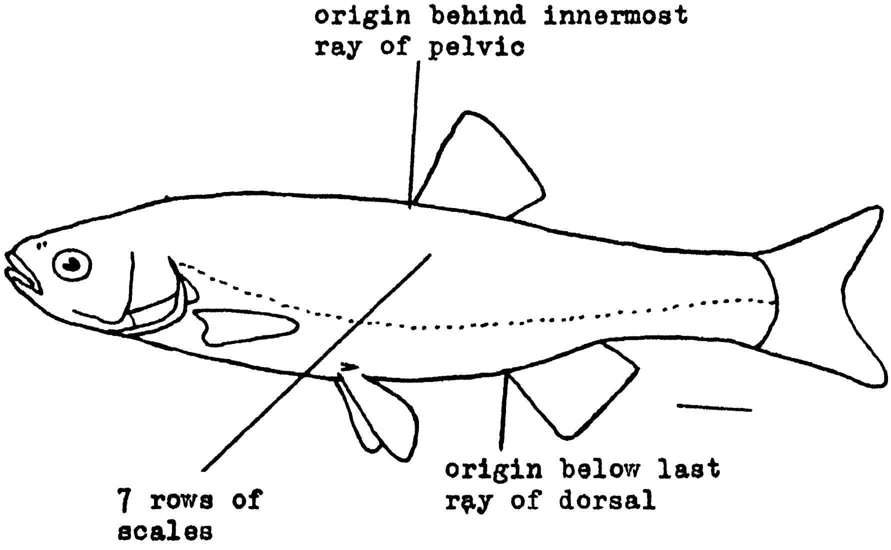

origin opposite innermost ray of pelvic
10 rows of scales
origin behind last dorsal ray

Figure 70. Leuciscus spurius


origin behind innermost ray of pelvic
7 rows of scales
origin below last ray of dorsal

of the eye, with the jaws even in front. The dorsal fin with 3 simple rays and 8 branched rays. The origin of the dorsal fin is behind the insertion of the pelvics. The origin of the anal fin is beneath the last ray of the dorsal. The anal fin has 3 simple rays and 10 branched rays. The lateral line count is 50.

Color: Generally silvery whitish, with back slightly darker.

This fish was taken from the Aleppo region. Its life history is somewhat similar to that of L. c. orientalis.

Genus Phoxinellus Heckel

Body medium, more or less compressed, covered with small scales. Mouth medium, terminal, without lips, no barbels. Suborbitals narrow, not covering cheeks, which are naked. Pharyngeal teeth conical, more or less hooked, disposed in a row on each side 5-5, or 4. Pseudo-branchiae present. Lateral line complete or incomplete, nearer the belly than the back, but becoming median on the caudal peduncle when it exists. Dorsal fin without bony ray, comprised of 9 to 11 rays, commencing sometimes over, generally in the rear of the pelvics. Anal short or medium with 9 to 14 rays, 7 to 11 of which are branched.

This genus is represented by six species in Syrian waters.

Key to the Species of Phoxinellus

1 a. Lateral line complete........................ P. zeregi
1 b. Lateral line incomplete
  2 a. Origin of dorsal in back of the pelvics
    3 a. Lateral line scales less than 45
      4 a. Anal rays 10...........................P. kervillei
      4 b. Anal rays 8............................P. rutiloides
    3 b. Lateral line scales more than 44
      5 a. More than 51 scales in lateral
         line.................................P. drusensis
      5 b. Less than 50 scales in lateral
         line ....P. syriacus

2 b. Origin of dorsal above the ventrals ....P. libani

Phoxinellus drusensis Pellegrin

The height of the body contained 3 to 3 2/3 times in the standard length, the length of the head 3 ½ to 4 times. The snout, rounded, is equal or a little smaller than the diameter of the eye, which is contained 3 to 4 times in the length of the head, 1 to 2 times in the interorbital space. The jaws are equal, the mouth obliquely split and directed, attaining the anterior border of the eye or nearly so. The gill rakers, thick, are 7 in number on the lower part of the first branchial arch. The pharyngeal teeth, hooked, are in a single row with a 5-4 formula. The lateral line count is 53-60 scales, 13-14 between the lateral line and the origin of the dorsal fin and 6 between the lateral line and the pelvic, 26-28 around the caudal peduncle. The lateral line is incomplete, extending 15-30 (exceptionally 40) scales. The dorsal origin is equal distant from the eye to the origin of the caudal, distinctly in back of the origin of the pelvic; it contains 2 or 3 simple rays, flexible, and 7 branched rays having 3/4 to 4/5 the length of the head; the superior border is slightly convex. The anal, equally rounded, formed of 2 or 3 simple rays and 6 branched rays, is far from reaching the caudal. The pectoral, rounded, has 3/4 to 4/5 the length of the head, and does not attain the pelvic. The pelvic is also rounded and does not reach the anal papilla. The caudal peduncle is 1 1/3 to 1 3/4 as long as high. The caudal is forked, the lobes rounded.

Color: Brownish on the back, sides lighter yellowish to silvery, belly silvery. A blackish band along the middle of the side.

This fish was taken from the Queiq and Saroute Rivers. Nothing is known of its life history.

Phoxinellus kervillei Pellegrin

The height of the body equals the length of the head, and is contained 3 ½ to 4 times in the standard length. The eye is contained

Figure 71. Phoxinellus drusensis

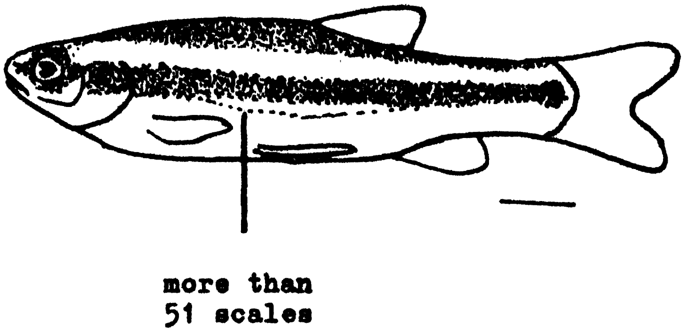
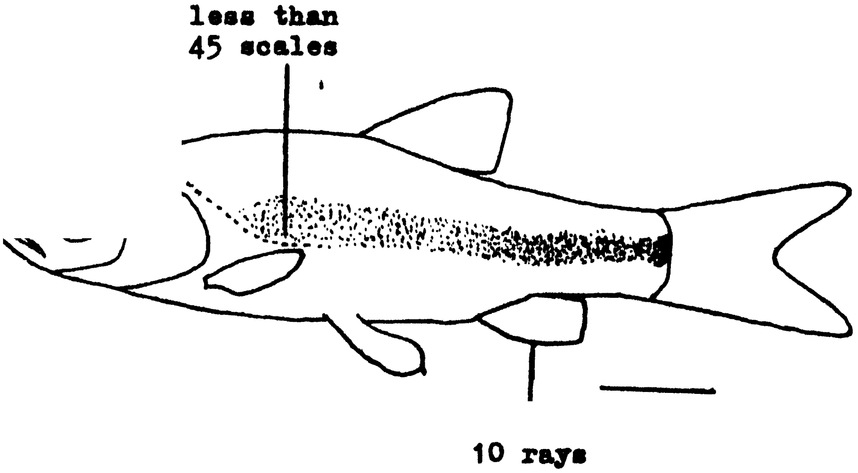


Figure 72. Phoxinellus kervellei



2 ½ (very young) to 3½ times in the head length; its diameter equals the interorbital space and is superior to the snout. The snout is obtuse, the mouth terminal, oblique, extending almost under the anterior border of the eye; the jaws nearly equal, the lower a little protuberant. The gill rakers are short and strong, and number 7 on the lower part of the first branchial arch. The pharyngeal teeth are uniseries, hooked, and number 5-4. There exists a pseudobranch. The body is entirely covered with scales, there being from 37 to 42 along the lateral line, which is incomplete with 12 to 20 scales being pierced, not passing the dorsal fin. There are 9 to 10 scales between the lateral line and dorsal fin, and 4 between lateral line and pelvic, and 18 around the caudal peduncle. The dorsal arises a little nearer the origin of the caudal than the tip of the snout, slightly behind the origin of the pelvics, and consists of 2 simple and 9 branched rays. The anal is almost as high as the dorsal and does not reach the caudal. The pectoral is nearly 2/3 the head length and does not reach the pelvic. The pelvic does not reach the anal. The caudal peduncle is 1 1/3 to 1 ½ times as long as high. The caudal is distinctly forked.

Color: Yellowish brown on the back, silvery on the sides, with a dark longitudinal band terminating in a black dot at the base of the caudal. All fins uniformly greyish.

This fish was taken in the Orontes River. Nothing is known of its life history.

Phoxinellus libani Lortet

No complete description of this species is presently available. The chief distinguishing characteristic of the species is that the dorsal fin origin is above the pelvics.

This fish is reportedly found in the upper Orontes.

Phoxinellus rutiloides Tortonese

Body rather short and high. The height is contained 3 times in the length, the head 3 2/3 in the standard length. The diameter of the eye equals

Figure 73. Phoxinellus rutiloides

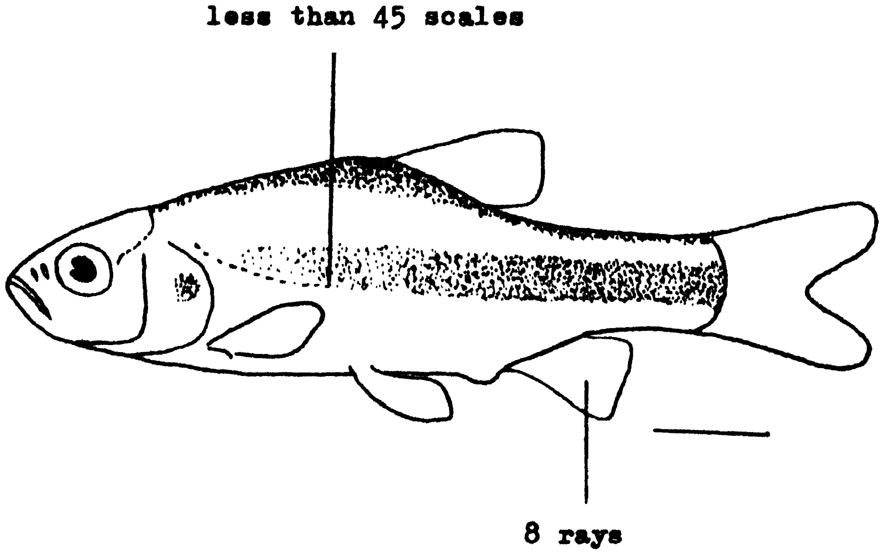
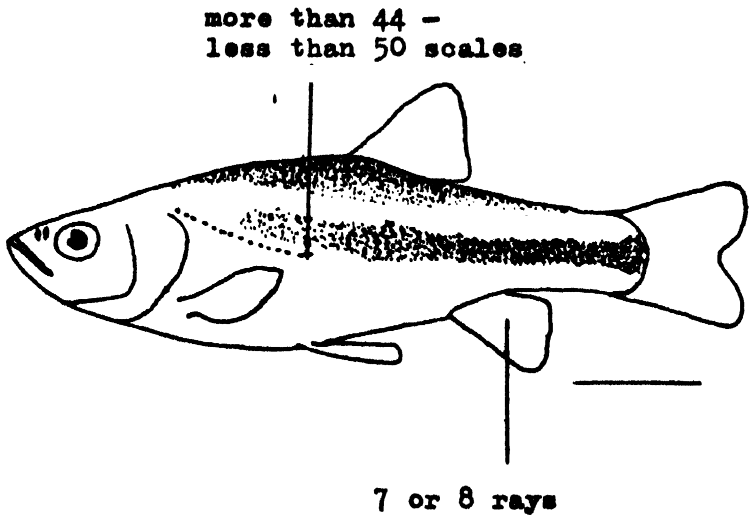


Figure 74. Phoxinellus syriacus



the snout, 1/4 the head, and 3/5 of the interorbital space. The mouth does not reach the eye, the lower jaw is slightly projecting. No barbels. No pseudobranchiae. Six gill rakers on the first arch. Pharyngeal teeth uncinate, one row, 4-4. Lateral line scales from 37 to 43, 8 from lateral line to the dorsal and 4 from lateral line to anal, 14 around caudal peduncle. Lateral line not complete, 17 to 24 tubules. Dorsal fin composed of two simple and seven branched rays; dorsal origin behind pelvics. Anal fin composed of two simple and 6 or 7 branched rays. Pectoral length about half the head length and not reaching the pelvics. Pelvics end before anal opening.

Color: Body darkish brown on back, sides yellowish brown, belly yellowish. A dark lateral line is present. Fins grayish.

This fish is found in the Orontes River. Nothing is known of its life history.

Phoxinellus syriacus (Lortet)

Body height contained 3 to 3.2 times in standard length, head 3.5 to 3.7 in same length. Eye is contained 3.6 to 4 times in head length. The mouth is oblique, reaching beyond the anterior edge of the eye, lower jaw slightly protruding. Lateral line scale count 46-48, with 12 to 17 pores. The dorsal fin insertion is behind the insertion of the pelvics. The dorsal fin is composed of 2 simple and 7 branched rays. The anal fin is composed of 2 simple rays and five or six branched rays. The pectoral fin is 3.5 the head length, rounded and does not reach the pelvics. The pelvics are rounded, and about 1/2 the head length, and do not reach the anus.

Color: Generally yellowish brown, dark median stripe down back, and dark lateral band present.

This fish was taken in the waters of the vicinity of Damascus. Nothing is known of its life history.

Phoxinellus zeregi Heckel

Mouth terminal, upper jaw scarcely overlapping the lower. Body somewhat compressed, its depth being equal to the head length, which is one-fourth the standard length. Gill rakers very short. Pseudobranchiae present. Dorsal fin with 2 simple and 8 branched rays. Anal fin with 2 simple and 7 branched rays. Lateral line scales 57-66. Lateral line pores complete. Pharyngeal teeth 5 - 5, slightly compressed, uncinate.

Color: Body yellowish brown, darker on the back. A broad dark lateral band present, which is darker on the caudal peduncle. Belly is light yellowish to silvery.

This fish is reported from the Orontes River. Nothing is known of its life history.

Genus Rutilus Rafinesque

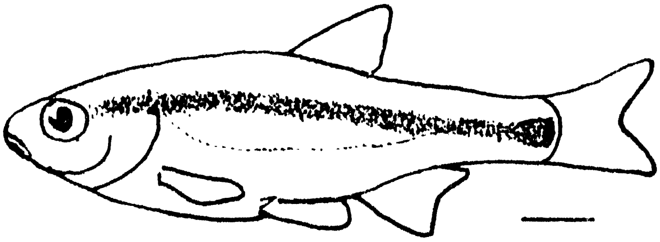
Body more or less compressed, covered with medium scales. Mouth medium or very large, without lips or barbels. Suborbitals small, cheeks naked. Pharyngeal teeth in a simple row 5 or 6 - 6 or 5, compressed, more or less hooked and beveled. Lateral line complete, more near the belly than the back, but median on the caudal peduncle. Dorsal short, without ossified rays, composed of 2 or 3 simple rays and 7 to 11 branched, commencing over the insertion of the pelvics or a little to the rear. The anal resembles the dorsal, formed of 3 simple rays and 8 to 11 branched. A scaled appendage at the base of the pelvics.

This genus is represented by one species in Syria.

Rutilus tricolor (Lortet)

The height of the body is contained 2 3/4 to 3 1/5 times in the standard length. The length of the head 3 1/4 to 3 2/3 in the same length.

Figure 75. Rutilus tricolor



The diameter of the eye is contained 3 2/3 to 4 2/3 times in the head length, 1 to 1 1/2 in the snout length and in the interorbital space. The mouth is oblique, very large, but does not reach past the anterior edge of the eye; the jaws are equal. The pharyngeal teeth are numbered 5 - 5. The scales, with few divergent striations, are numbered from 5 to 6 between the lateral line and the pelvic, 11 to 12 between the lateral line and the dorsal and 54 to 58 in the lateral line, and 20 around the caudal peduncle. The dorsal origin is about equal distant from the center of the eye to the origin of the caudal; its longest rays are 3/5 to 3/4 the head length; its superior border is slightly convex, the rays include three simple and 7 or 8 branched. The anal has its insertion equal distant from that of the dorsal and has its rays a little less long, with three simple and 9 or 10 branched. The pectoral is rounded and 2/3 the head length. The pelvics arise in front of the dorsal, its last ray corresponding to the first of the dorsal. The caudal peduncle is 1 1/2 to 2 times as long as high. The caudal is forked, the lobes pointed.

Color: Reddish brown on the back, silvery white on the belly with a longitudinal band of steel blue on the sides, whence the specific name tricolor.

This fish was taken from the Barada and Awaj Rivers. Nothing is known of its life history.

Genus Tylognathus Heckel

Scales of moderate size. Dorsal fin without osseous ray, with not more than 9 branched rays, commencing somewhat in advance of the pelvics. Snout obtusely rounded, the skin of the maxillary region being thickened, swollen, forming a projection beyond the mouth. Mouth essentially as formed in genus Labeo (mouth transverse, inferior, with the lips thickened, each or one of them being provided with an inner transverse fold, which is covered with a deciduous horny substance forming a sharp edge, which, however, does not rest upon the bone as the base, but is soft and movable). Barbels very small, two or four, the maxillary barbels hidden in a deep groove behind the angle of the mouth. Anal scales not enlarged. Anal fin short. Snout frequently with tubercles and/or pores. Pharyngeal teeth uncinate, 2, 4, 5 - 5, 4, 2.

This genus is represented by one species in Syria.

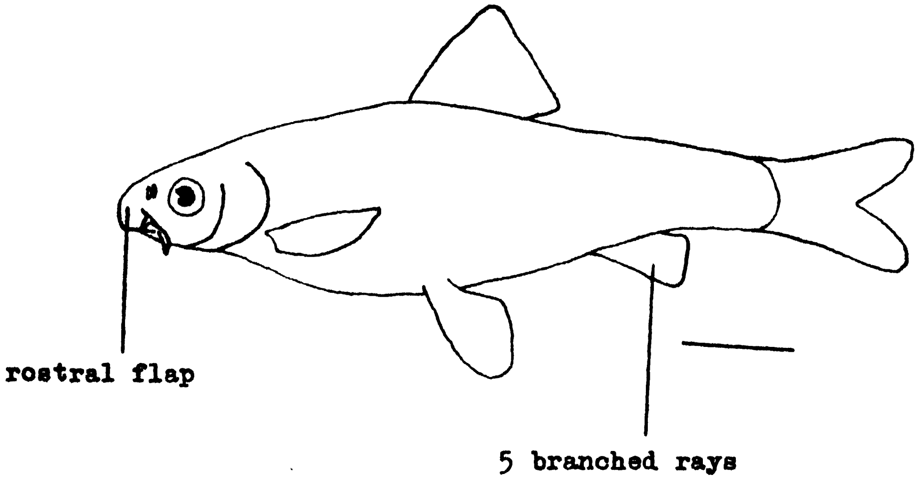
Tylognathus nanus Heckel

Body sub-cylindrical, its height is contained 2 3/4 to 3 3/4 times in the standard length, the length of the head 3 3/4 to 4 1/4 times. The snout is rounded, moderately proturberant. The eye is superior-lateral, comprising a major part of the anterior half of the head and is contained 3 1/4 to 4 1/4 times in the head length. The mouth is transverse, the width about 1/3 and head length; the jaws are sharp, chiefly inferior, but they are not sheathed in horn; the lips well developed; it has two pairs of small barbels, the anterior of which is the smallest, the posterior being smaller than half the eye diameter. Lateral line scales 31 to 35, 6 above lateral line to dorsal and 4 or 5 between lateral line and pelvic, 16 around caudal peduncle. The dorsal begins an equal distance between the snout and the origin of the caudal, and consists of 3 simple rays and 8 branched rays, the longest being 2/3 to 4/5 the head length. The anal is composed of 2 simple rays and 5 branched rays, which do not reach the caudal. The pectoral is pointed and is 2/3 to 3/4 the head length and does not reach the pelvics. The pelvics are inserted beneath or a little in back of the region of the dorsal. The caudal peduncle is a little longer than high. The caudal fin is strongly emarginate.

Color: Olivaceous to brownish yellow on top, whitish underneath with silvery reflections and a longitudinal dark band extending from high at the gill opening to the end of the caudal peduncle.

This fish was taken from the waters near Damascus, the Orontes, the Yarmuk and Lake Tiberius. Nothing is known of its life history.

Figure 76. Tylognathus nanus



Genus Varicorhinus Ruppell

Body compressed, covered with small, moderate or large scales. Lateral line complete, running closer to belly than back, but median on caudal peduncle. Mouth large, inferior, transverse, feebly protractile, without lips, the upper partly covered with a rostral fold, the lower completely exposed and showing a sharp cutting edge covered with a horny sheath. Barbels present or absent, suborbitals not covering the cheek. Dorsal fin with or without osseous ray, with 11 to 14 rays, 8 to 11 of which are branched. Anal fin short, with 7 or 8 rays. Pharyngeal teeth in three series, 2, 3, 4 or 5 - 5 or 4, 3, 2, with spoon-shaped crowns. A scaled appendage at base of the pelvics. Nuptial tubercles frequently developed on head and sometimes on the body.

This genus is represented in Syria by 5 species.

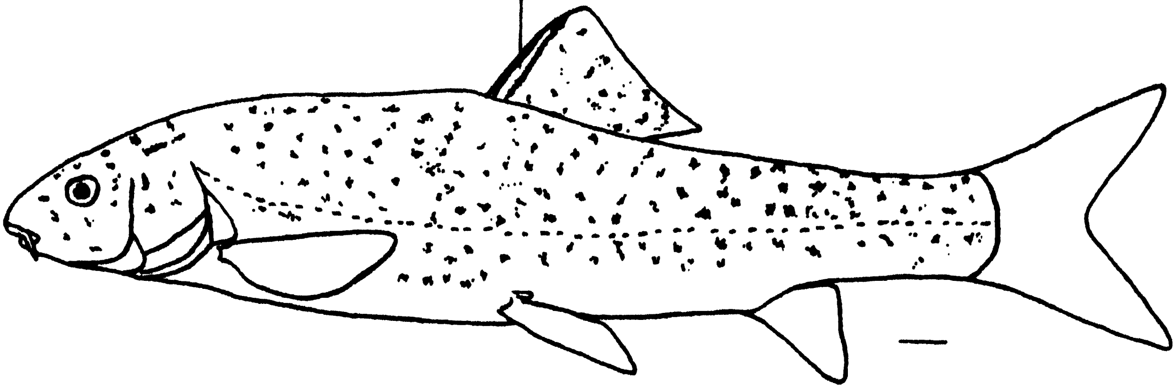
Key to the Species of Varicorhinus

1 a. No osseous dorsal spine .... V. syriaca
1 b. Osseous dorsal spine present
  2 a. Dorsal spine weak; body not spotted
    3 a. Lateral line scales less than 89.......... V. damascinus
    3 b. Lateral line scales more than 88 .... V. umbla
  2 b. Dorsal spine strong; body spotted
    4 a. Spine longer than head length .... V. trutta
    4 b. Spine shorter than head length .... V. barroisi

Varicorhinus barroisi (Lortet)

The body is compressed on the sides, the height is contained 3 1/3 to 4 3/4 in the length without the caudal, the length of the head 4 1/4 to 4 3/4. The snout is rounded, more or less covered with tubercles in adult males. The diameter of the eye is contained 4 1/4 times in the young to 7 times in the adult in the head length; 1 1/2 times in young to 2 1/2 times

Figure 77. Varicorhinus barroisi



strong spine,
shorter than head

in adult in the snout length; 1 1/2 times (young) to 3 times in the interorbital space. The mouth is inferior, transverse, its breadth is contained 3 times (adult) to 4 times (young) in the head length. The lips are little developed, the inferior limited to the sides of the mouth. At each buccal angle there is a small barbel about 1/2 the eye diameter. There are 72-81 scales on the lateral line, 16-18/20-23 on the transverse line, 9-12 between the lateral line and the pelvic, 28-34 around the caudal peduncle. The scales on the belly and in front of the pelvics are very small, and not regularly imbricated. The dorsal fin begins an equal distance from the tip of the snout and the origin of the caudal; it is formed of 3 simple rays and 9-10 branched rays. The third simple ray constitutes a strong spine bearing a double row of teeth on the posterior border, and is proportionately longer in the young, where it attains nearly the head length, while in the adults it is only about 1/2 the head length. The denticulations uniformly do not extend more than 2/3 of the height of the spine in the adult, while in the young they extend almost the height. The fin is a little less high than long (young) and longer than high in the adults.

The anal fin is composed of 2 simple rays and 6 branched rays and does not reach the caudal. The pectoral is rounded slightly, and is nearly as long as the head, and terminates a distance from the pelvic. The pelvic origin is behind the origin of the dorsal and nearly equals the pectoral, and does not reach the anus. The caudal peduncle is 1 1/2 to 2 times as long as high. The caudal is distinctly forked.

Color: Back and sides slate to violet, with belly yellowish. A multitude of small brownish to blackish dots cover the body and fins.

This fish is reported from the Orontes River and its tributaries, the Queiq River, the lake at Homs and Ouadi Roumelane. Nothing is known of its life history.

Varicorhinus damascinus Cuvier and Valenciennes

The height of the body is contained 3 1/2 to 4 times in the standard length; the length of the head 4 1/3 to 5 times. The snout is obtuse and rounded. The eye is visibly more up than down, its diameter is contained 4 2/3 to 6 3/4 times in the head length, 2 to 3 times in the length of the snout and in the interorbital space. The mouth is inferior, round, and forms a crescent, with the upper lip smooth bordered and the lower jaw has a horn rim; its width is contained 3 to 3 1/2 times in the head length. There is one pair of barbels equal or slightly longer than the eye diameter. The pharyngeal teeth are of the number 2, 3, 4 - 4, 3, 2. The lateral line scales vary from 61 to 78, transverse counts from 12-15/18-20, with 9-12 between lateral line and pelvic, and 26 to 30 around caudal peduncle. The dorsal commences about an equal distance from the tip of the snout to the origin of the caudal; its third simple ray is somewhat ossified, finely toothed behind; its length about 2/3 to 3/4 that of the head, 1 1/3 times that of the base of the fin, the upper edge of it is straight; it has 8 or 9 branched rays. The anal may or may not reach the caudal, and contains three simple rays and 5 branched rays. The pectoral, rounded, is about 5/6 the head length and is separated from the pelvic by an equal distance or less than its own length. The pelvic arises under the first rays of the dorsal and almost reaches the anus. The caudal peduncle is 1 1/2 to 1 3/4 times as long as high. The caudal is forked, the lobes generally rounded, at times pointed.

Color: Generally brownish on the back, with the sides whitish or yellowish, and the belly with silverish reflections. The fins are uniformly brownish or greyish.

This fish is found in many waters of Syria. A study must be made of this species, since it appears that there are several variations in scale counts to be found, and it is likely that this species may be divided into several subspecies. Earlier workers described several species for this region, but it has been found that there is a great overlap in the scale counts which were the major separation of the species, and therefore it seems likely that subspecific designation would be more practicable.

Figure 78. *Varicorhinus damascinus*

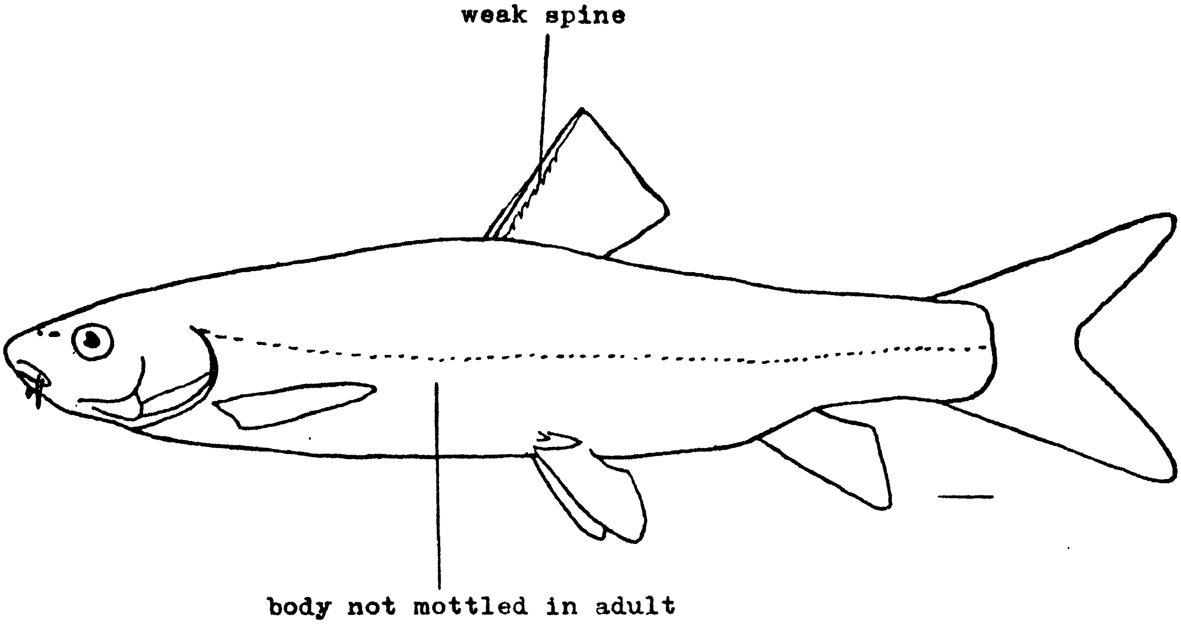
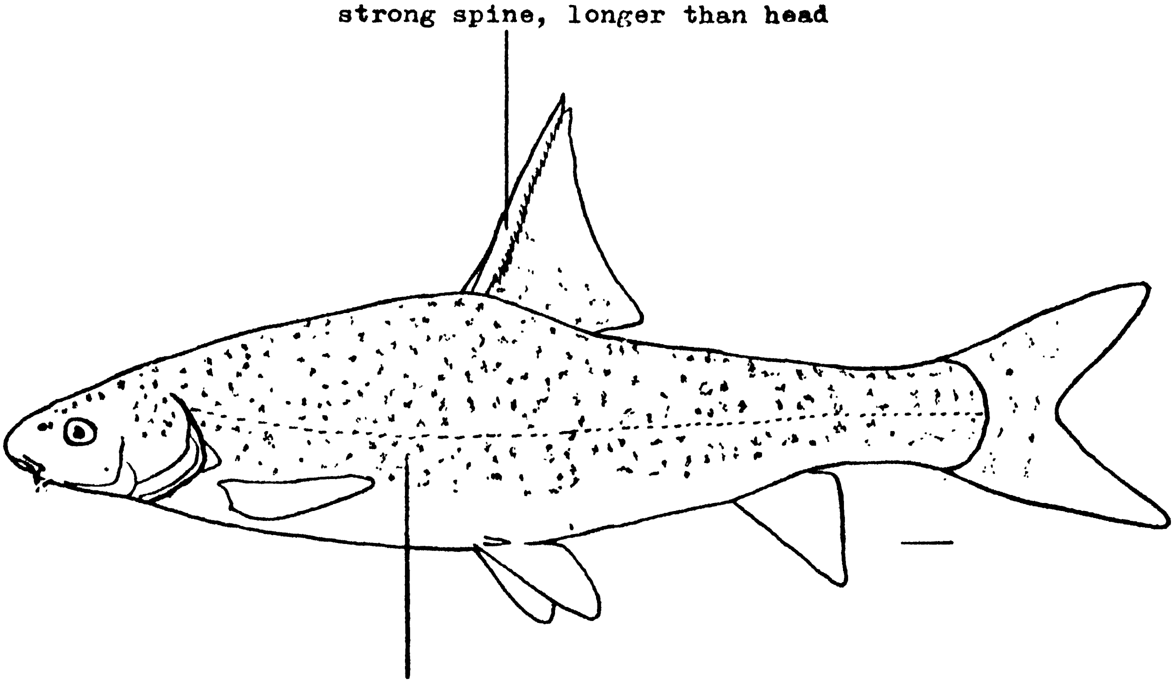


Figure 79. *Varicorhinus trutta*



Little is known of this species life history. Specimens of 30 centimeters in length and a weight of 500 grams have been taken. It is primarily an herbivore.

Varicorhinus syriaca Cuvier and Valenciennes

The height of the body is more than the length of the head, which is 1/5 the standard length. The snout is thick and rounded. Two barbels only at the corners of the mouth. The eye is small. The dorsal fin with three simple rays and 9 branched rays, the third ray is not osseous. The anal fin is composed of two simple rays and five branched rays. The lateral line scale count is 80.

Color: Generally brownish on the back and sides, yellowish to whitish on the belly.

This fish might be found in the Jordan River. Nothing is known of its life history.

Varicorhinus trutta (Heckel)

The osseous ray of the dorsal fin is very strong, and considerably longer than the head, strongly serrated. The origin of the dorsal fin is midway between the tip of the snout and the root of the caudal. The dorsal fin consists of three simple rays and nine branched rays. The anal fin is composed of two or three simple and five branched rays. The lateral line scales number 77-82, 16/22 on the transverse line. The eye is small. The head length is 1/5 the standard length. The scales on the abdomen are very small.

Color: Generally brownish to yellowish on the sides and back, the belly lighter in color. Head and body covered with black dots.

This fin was taken from the Euphrates, Khabour and from the Tigris Rivers. Nothing is known of its life history.

Varicorhinus umbla Heckel

The head length is one-fifth of the standard length; the eye is rather small; the snout is obtuse. The origin of the dorsal fin is somewhat nearer to the end of the snout than to the root of the caudal. The dorsal fin has three simple and 11 soft rays, the third ray is feebly osseous and finely serrated. The anal fin has three simple and 5 branched rays, and is deep and narrow. The lateral scale count is 90 to 96 scales.

Color: Generally brownish on the back, with the sides lighter.

This fish was taken from the Tigris River. Nothing is known of its life history.

Family CYPRINODONTIDAE

Body covered with scales. Head scaled. Mouth very protractile covered with teeth, edges formed by the premaxillaries only. Maxillaries small. Pharyngeal teeth generally cardiform; inferior pharyngeals distinct. No barbels. Branchiostegals numbering 4-6. Four branchial arches. Opercular apparatus well developed. Gill membranes free. Lateral line absent or reduced to small points. Unpaired fins greatly different in the two sexes. Dorsal unique, formed of soft rays, few in number. Anal short or medium. Pectorals situated more or less low. Pelvics composed of 5 to 7 rays, rarely absent. Swim bladder simple, sometimes absent. No adipose fin. Stomach without caecae; pyloric appendages none. No pseudobranchiae.

One genus represents this family in Syrian waters.

Genus _Aphanius_ Nardo

Body thick set, oblong, covered with large smooth scales, no denticles. Head flattened on top. Mouth small, covered with a single series of medium tricuspid teeth. Inferior pharyngeals separated, covered by small pointed teeth. Dorsal rather far back, usually arising in front of the anal; the latter composed of 9 to 14 rays; the two fins more developed in the male than in the female. Pectorals inserted on the lower sides of the body. Pelvics present, located far behind the pectorals.

Three species represent this genus in Syrian waters.

Key to the Species of _Aphanius_

1 a. Two crescent-shaped bands on the tail .... _A. dispar_
1 b. No crescent-shaped bands on the tail
  2 a. Eye diameter one-third head length; and almost equal to interorbital space .... _A. sophiae_
  2 b. Eye diameter one-fourth head length, and one-half interorbital space .... _A. mento_

Aphanius dispar (Ruppell)

The height of the body is equal to the length of the head, and is contained 3 2/3 in the total length; head thick, snout obtuse. The diameter of the eye equals the length of the snout, is rather more than one-half the width of the interorbital space, and contained 3 2/3 in the head length. Dorsal and anal fins are elevated in males, and extending to the caudal if laid backwards. Dorsal fin rays 9, anal fin rays 10. In males, the origin of the dorsal fin is midway between the root of the caudal and the preoperculum, and corresponds to the 11th scale of the lateral line. The first anal ray is below the sixth of the dorsal. The caudal fin is rounded. The lateral line scale count is 25-27.

Color: Body without silvery crossbars, but with irregular reticulated markings in young; body generally brownish in color. Caudal fin with two crescent-shaped brown cross bands.

This fish is probably to be found in the Tigris and Euphrates Rivers. Nothing is known of its life history.

Aphanius mento Heckel

The height of the body equals the head length, which is two-sevenths of the standard length. The diameter of the eye is one-fourth the head length, and one-half of the width of the interorbital space. The pelvic fins scarcely in advance of the middle of the standard length, but conspicuously in advance of the dorsal. Dorsal rays 2 simple and 10 branched. The anal fin is composed of 2 simple and 9 branched rays and commences below the middle of the dorsal, with the hinder third of the standard length. Dorsal and anal fins not elevated. Lateral line scale counts 27.

Color: Male, dark brown, with fins black and white dotted. Female, lighter in color with uniform whitish fins.

Nothing is known of its life history.

This fish was taken from the Orontes, Barada, Awaj, Afrin Rivers, and the Springs at Jeirrud and Muzerib, and Homs Lake.

Figure 80. Aphanius dispar

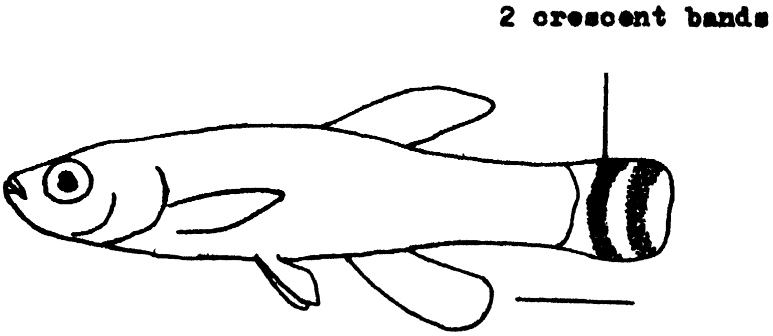


Figure 81. Aphanius mento

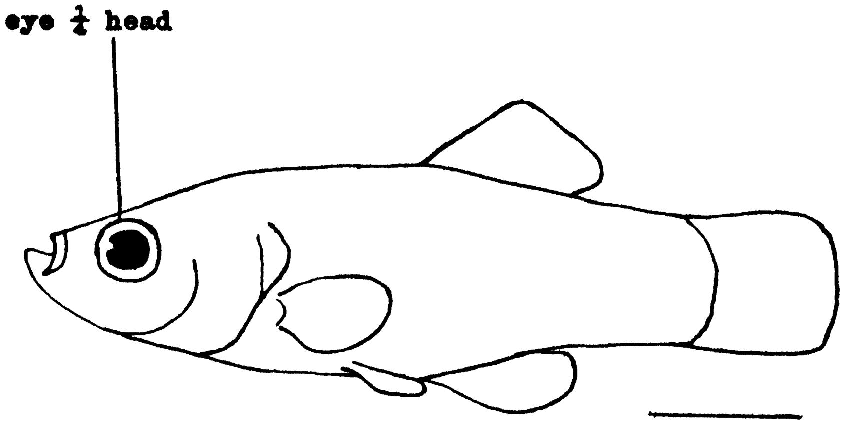
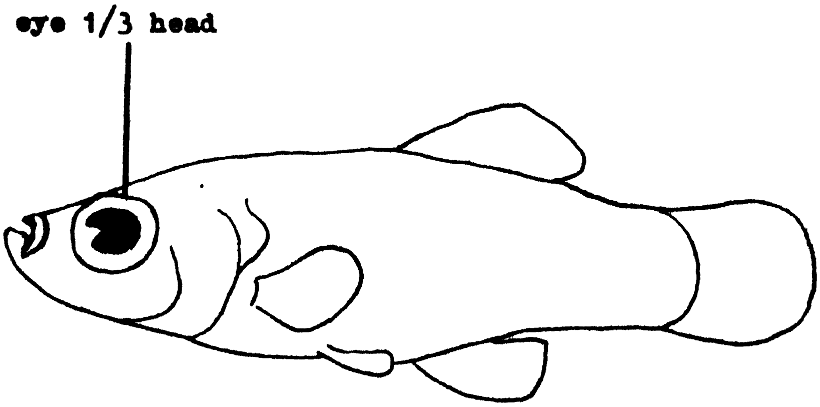


Figure 82. Aphanius sophiae



Aphanius sophiae Heckel

The body height is contained 2 1/2 to 3 1/2 times in the standard length, the head length 3 to 3 1/3 times. The superior profile is straight. The eye diameter is contained 2 1/2 to 3 1/4 times in the head length, o to 1 1/3 in the interorbital space. The mouth, terminal, is directed upwards when it is retracted. The eye diameter is more than the length of the snout. There are 16 tricuspid teeth on each jaw, the median point is a little longer than the lateral points. There are 14 scales in the transverse line, 18 around the caudal peduncle, and 27 to 30 in the lateral line, which is very indistinct or missing. The dorsal origin is nearly equal distant from the opercular slit to the origin of the caudal; its longest ray is 1/2 or a little more than 1/2 the head length; its superior border is convex, and is composed of 2 simple and 9 branched rays. The anal is similar in shape and is composed of 1 simple and 9 branched rays. The pectoral is rounded and equals about 2/3 the head length. The pelvics measure 1/2 the head length and commence a little nearer the origin of the caudal than the tip of the snout. The caudal peduncle is nearly as long as high. The caudal is rounded.

Color: In males, the general color is light brown with 9 to 11 silver bars, but at times the males may be dark blue in color, almost to black. The dorsal fin may be bluish or blackish in color with silvery or bluish spots forming transverse lines. The caudal may be barred with several thin transverse lines of dark. The anal fin is also banded.

In the female, the color is lighter, usually brownish, and usually spotted with a series of small brown spots, somewhat in longitudinal lines.

This fish has been taken from the Orontes, the Khabour River, and the Farsraya springs at Douma.

It grows to a length of a little more than 50 millimeters. It feeds upon plankton, and midge and mosquito larvae and pupae. It is primarily a surface feeder, with its upturned mouth.

Family GASTEROSTEIDAE

Form of body elongated, compressed; eyes lateral; cleft of mouth extending on the sides of the muzzle, oblique; villiform teeth in both jaws and on the pharyngo-branchials, none on the palate or on the tongue. Three branchiostegals. Opercular bones not armed; infraorbital arch articulated with preoperculum; parts of the skeleton forming external mails. Scales none, or in the form of scaly plates only on the sides. Isolated spines before the dorsal fin; pelvic fins abdominal but pubic bones attached to humeral arch; pelvic with one strong spine, and generally with another single short ray. Swim bladder simple, oblong; pyloric caecae in small number.

This family is represented by one genus in Syria.

Genus Gasterosteus Linnaeus

Body elongated; independent dorsal spines usually 3, but sometimes 2 or 4; the main characteristic of the genus is the small number and large size of these dorsal spines, the anterior two being especially strong; gill clefts distinct one from the other under the throat; sides usually bearing bony plates or shields; height of the body about 1/4 the standard length.

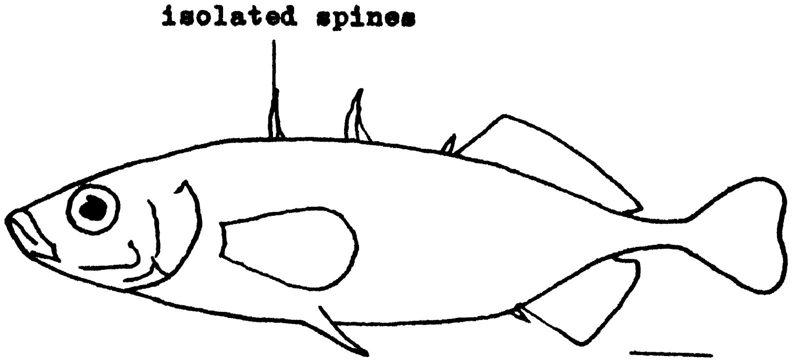
This genus is represented in Syria by one species.

Gasterosteus argyropomus Cuvier and Valenciennes

Sides without any plates. The anterior spines about one-third the height of the body. Dorsal fin commencing last third of the body, with 12 rays. Anal fin shorter than dorsal, commencing behind dorsal insertion, composed of one spine and 10 branched rays.

Color: Back generally brownish-green, more pale on the sides with reflections of silvery, and white on the belly with dark spots of varying size and number. There is considerable color variation between individuals.

Figure 83. _Gasterosteus argyropomus_



This fish generally measures up to 5 or 6 centimeters in length, and a weight of a few grams. It feeds on plankton and small crustaceans, insect larvae, eggs of fish, and small fry. The eggs are relatively large, measuring 1 1/2 to 2 millimeters in diameter, and each female may lay as many as 300 eggs. The male constructs a nest by making a hollow in the bottom muds and builds over the hollow an intertwining net of aquatic vegetation. After the eggs are laid the male guards the eggs and fry until they can attend to themselves.

Family MASTACEMBELIDAE

Body eel-like, compressed and elongated, covered with minute scales; non-protractile mouth and elongated snout supported by a cartilaginous rod and ending in a sensitive tip flanked by the tubular anterior nostrils, which are thus remote from the posterior; palatines flake-like, fused to the ethmo-vomer; long soft dorsal and anal fins, preceded by 7 to 40 detached, depressible dorsal spines, and 1 to 3 anal spines; pelvic fins absent; post temporal bone (except its lateral line component) absent; pectoral girdle not attached to skull; caudal short, either confluent with dorsal and anal, or narrowly separated; air bladder without an open duct.

One genus represents this family in Syria.

Genus Mastacembelus Gronovius

Premaxillary simple, not prolonged far in front of tip of lower jaw as a paired series of toothed plates; snout conical with tubular anterior nostrils opening near its tip, supported internally by a rod-like rostral cartilage.

This genus is represented in Syrian waters by one species.

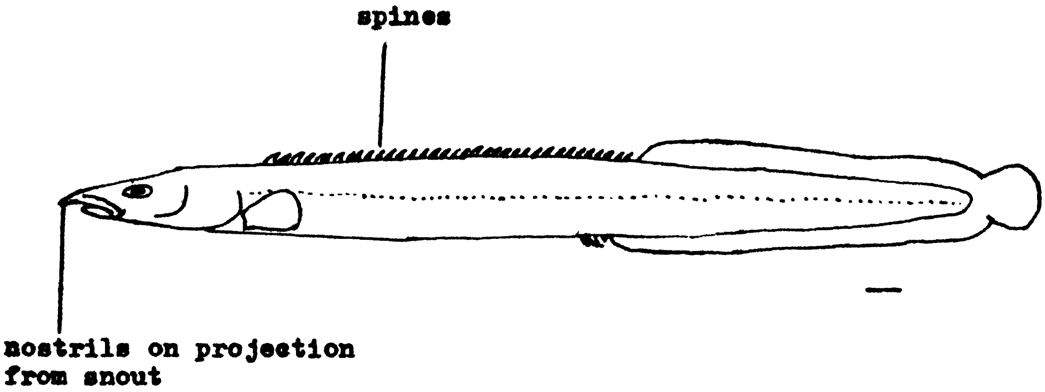
Mastacembelus mastacembelus (Solander)

Scales present around lower half-circumference of eye, below posterior nostril and between the latter and the maxilla; space between posterior nostril and eye, top of snout, internasal and interorbital spaces and top of head as far as hind edge of preoperculum naked. No spines on preoperculum. One strong preorbital spine piercing the skin or not pungent. Gape of mouth to below posterior nostrils or anterior border of eye. Teeth in broad bands in both jaws, the outer larger and sharp. No gill rakers. Spinous dorsal originating above posterior third of pectoral fin; with 31 - 35 spines; last dorsal spine small hidden beneath the skin. Anal spines together, 3 in number, second largest, last small and hidden in skin. Soft dorsal with 70-90 rays, soft anal with 72-90 rays. Soft anal originating slightly in advance of the soft dorsal.

Color: Body pale brown, becoming darker on back. Dusky bars and blotches along entire side, sometimes confluent into reticulate patterns. The higher ventral surface sprinkled with yellowish spots. Vertical fins yellowish, dorsal and caudal striated with minute dusky bars, and anal less striated, with bars and spots which may be confluent with the bars of the body. Pectorals yellowish and barred with rows of minute dusky spots.

This fish was taken in the Euphrates and Khabour Rivers, and is reported from the Kueik river, but was not taken in the present collections from the Kueik. This eel is widely distributed in the Euphrates drainage and is found in still and running waters, in clear as well as muddy water, usually lurking in crevices of the rocks and among vegetation near the banks. Nothing is known of its life history. In the far eastern countries where other species of this genus are found, they are eaten and considered a very good fish. In Syria, however, they are called snakes and are not taken for food.

Figure 84. Mastacembelus mastacembelus



Family MUGILIDAE

Body more or less oblong and compressed, covered with cycloid scales of moderate size; lateral line absent. Cleft of mouth narrow or of moderate width, without or with feeble teeth. Eye lateral, well developed. Gill opening wide; Four gills; pseudobranchiae present; five or six branchiostegals. Two short dorsal fins, distinct and separate, the anterior with four stiff spines; the anal a little longer than the posterior dorsal. Pelvic fins with one spine and five rays, abdominal, suspended from the elongate coracoid bone.

This family is represented by two genera in Syrian waters.

Key to the Genera of Mugilidae

1 a. Anterior edge of maxilla straight;
large adipose eyelid present .... Mugil

1 b. Anterior edge of maxilla angular, bent downward at
the corner of the mouth; no adipose eyelid
present (or poorly developed if present) .... Liza

Genus Liza Jordan and Swain

Upper lip thin to moderately thick, terminal, not papillate; lower lip thin-edged, directed forwards; teeth setiform, ciliiform or absent in upper lip, ciliiform or absent in lower lip; teeth present on palate; lower jaw wider than long, with a straight or slightly curved edge; symphysial knob present; premaxilla bent down posteriorly; maxilla bent down over premaxilla, either in a uniform curve or with an S-shaped curve at the end, and with a pronounced angle in the anterior view; the end of the maxilla makes an angle with the corner of the mouth instead of continuing the line; preorbital ridged, bent down behind the maxilla, its anterior edge curved, angular or almost straight; nostrils fairly close together; adipose eyelid sometimes present, never so well developed as in *Mugil*; stomach with well-developed biconical gizzard; pyloric caeca 2 - 14.

Key to the Species of *Liza*

1 a. Upper lip papillate, thick .... *L. labrosus*
1 b. Upper lip not papillate, thin
  2 a. Predorsal scales multicanaliculate .... *L. saliens*
  2 b. Predorsal scales unicanaliculate
    3 a. Soft anal rays 8 .... *L. abu*
    3 b. Soft anal rays 9
      4 a. Pectoral fin 1.15 to 1.35 in head;
          longer than head without snout .... *L. auratus*
      4 b. Pectoral fin 1.4 - 1.85 in head;
          shorter than head without snout .... *L. capito*

Liza abu (Heckel)

Length of head 24-29% of the standard length and 3.45 to 4.17 in it, greatest width of head 14.6 - 19.2%; interorbital width 8.7 - 10.9 %, diameter of eye 3.1 - 4.4 in head. Head as deep as wide, profile blunt, snout wide and shorter than the eye. Upper lip thin. Teeth small and setiform in upper lip, absent on lower lip. End of maxilla with an S-shaped bend in lateral view, its tip exposed during life. Anterior edge of the preorbital angular, bent down at the corner of the mouth, its end wider than the distance between the nostrils, denticulate. Lower jaw wider than deep, edge of mandible straight. Adipose eyelid absent.

First dorsal spine much nearer to the tip of the snout than than to the base of the caudal fin, very long and stout, 19-24% of the standard length. Second dorsal fin I,8; Anal fin III, 8, its origin just in advance of that of the second dorsal; both fins lightly scaled. Pectoral fin 16.4 - 18.1 % of the standard length and 1.38 to 1.70 in head. Axillary process absent. Pelvic fin inserted just in advance of the first

Figure 85. Liza abu

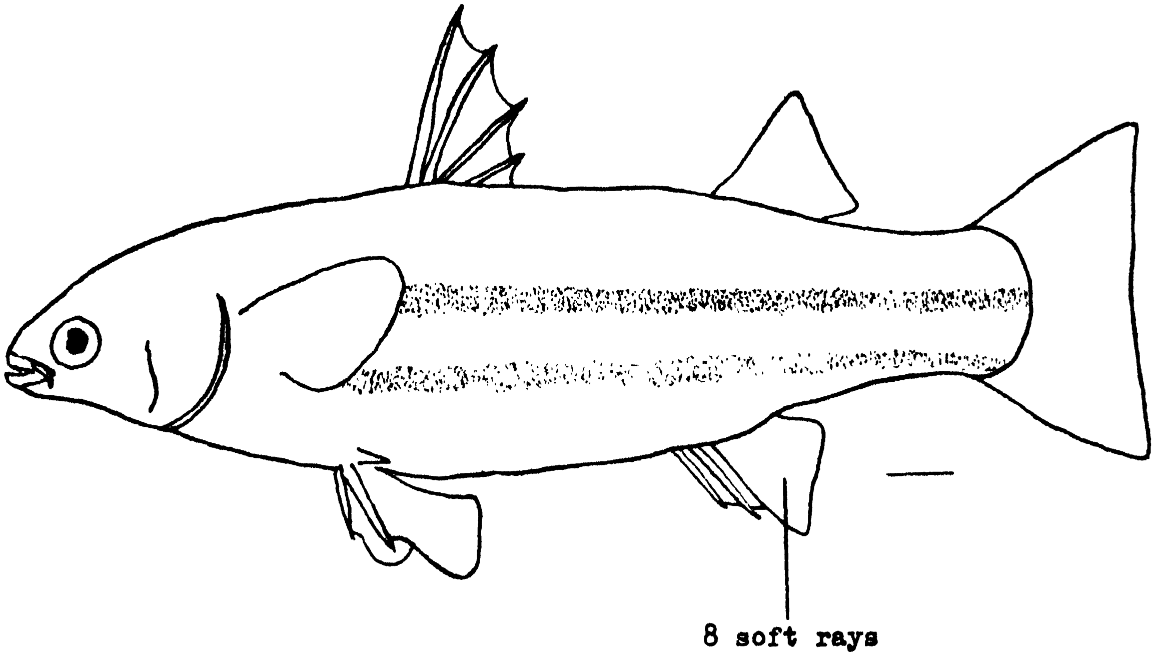
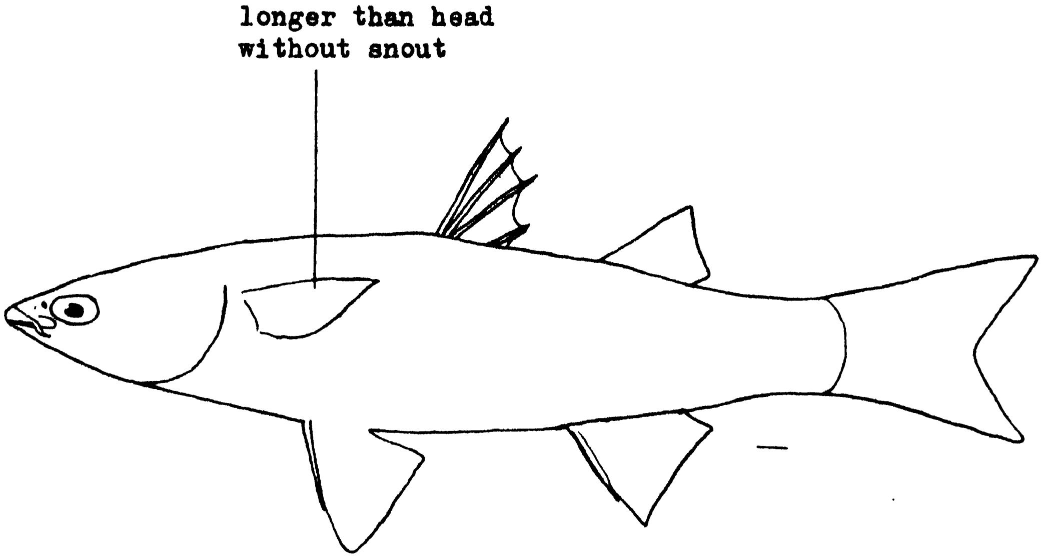


Figure 86. Liza auratus



dorsal. None of these fins is falcate. Caudal fin emarginate, caudal peduncle 1.5 - 1.8 times as long as deep. Anal and pelvic spines very stout.

Scales in longitudinal series 42-45, strongly ctenoid. Scale canals short and pit-like. No multicanaliculate scales. Gill rakers short, 44-55. Pyloric caecae, 4.

Color: Dark dorsally, light ventrally, with a dark longitudinal stripe, just below level of pectoral fin.

This fish was taken from the Euphrates, Tigris and Khabour Rivers and Lake Khatuniyeh. It has become acclimated to fresh waters, remaining continually in the fresh water. It spawns in the spring, especially in the Khabour River. It may reach a length of about 30 centimeters. It is primarily a plankton-vegetation eater.

Liza auratus (Cuvier)

The height of the body is contained five times and one-fourth to five times and three-fourths in the total length, the length of the head 5 times. The snout is broad and depressed; the interorbital space is slightly convex, its width being 2/5 of the head length. The upper lip does not show anything particular, and is not covered by the nasal bones. The angle made by the two mandibularies is rather obtuse, and the cleft of the mouth is more than twice as broad as it is deep; the preorbital has a longitudinal ridge covered with skin, and only the outermost extremity of the maxillary bone projects beyond its margin. Eyes with a rudimentary adipose membrane; nostrils close together, they are less distant from each other than the posterior is from the eye. A short lanceolate portion of the chin is not covered by the mandibularies. There are 25 scales between the snout and the spinous dorsal. The two anterior dorsal spines are nearly one-half of the length of the head. No pointed scale in the axil of the pectoral. There are 42-45 scales in the longitudinal line, the

13, 14, and the 26th scales of the line correspond to the extremity of the pectoral and to the origin of the two dorsal fins. The root of the pectoral is above the middle of the body; the pelvic is inserted midway between the pectoral and the spinous dorsal.

Color: Body dusky gray, belly silvery. A series of dark stripes on back and upper wides.

This fish is found on occasion in the lower reaches of the coastal rivers along the Mediterranean coast. A length of 20 to 45 centimeters is reached. This fish is considered very good eating.

Liza capito (Cuvier)

The height of the body is contained 5 times or 5 1/3 times in the total length, the length of the head 4 1/2 times. The snout is broad and depressed; the interorbital space slightly convex, its width being contained 2 1/2 to 2 1/3 in the head length. The angle made by the mandibulary bones is rather obtuse; the preorbital has an obtuse longitudinal ridge, and does not entirely cover the maxillary bone. Eyes without adipose membrane. Nostrils close together, they are less distant from each other than the posterior is from the eye. The lips are not covered by the nasal bones. The space at the chin, between the mandibularies and the interopercula, is rather broad, elongate and cuneiform. There are 28 or 30 scales between the snout and the spinous dorsal. The two anterior dorsal spines are nearly half as long as the head. There are 45 scales in the lateral line, the 8th or 9th, the 12th or 13th, and the 24th or 25th scales of the line correspond to the extremity of the pectoral, to the origin of the two dorsal fins. The root of the pectoral is above the middle of the body; the pelvic is inserted midway between the pectoral and the spinous dorsal.

Color: Back brownish with metallic reflections, the belly silvery gray.

This fish is also found on occasion in the lower reaches of the coastal streams of the Mediterranean. A length up to 50 centimeters may be reached. It is a good eating fish.

Figure 87. Liza capito

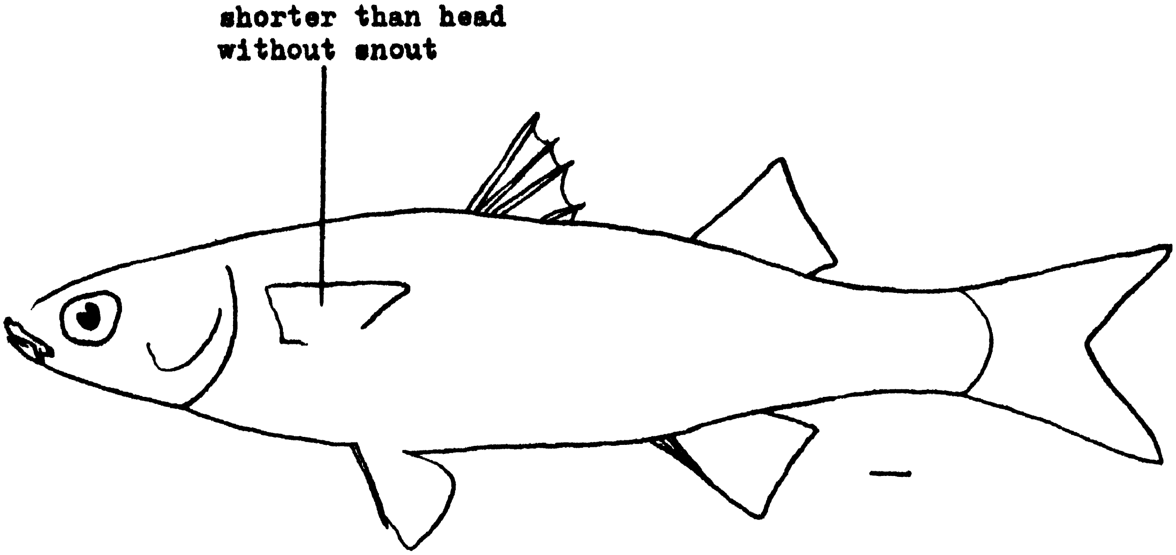
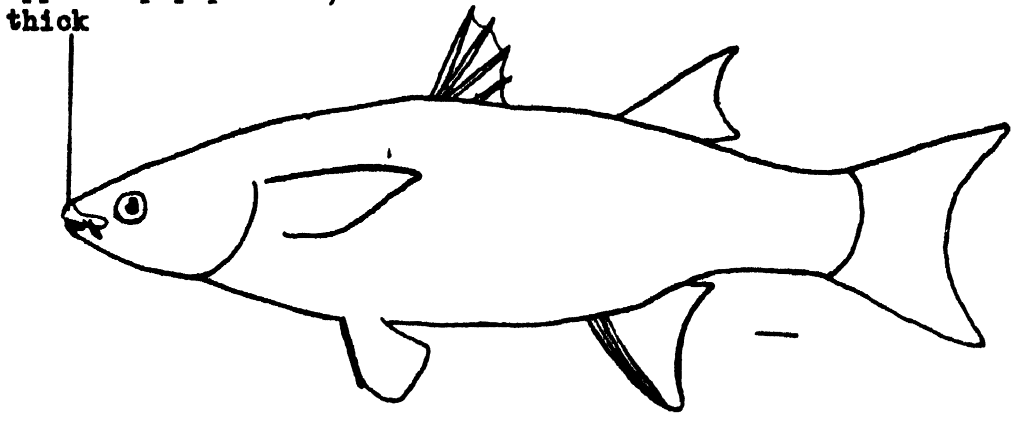


Figure 88. Liza labrosus



Liza labrosus (Risso)

The height of the body is contained 4 2/3 or 5 times in the total length, the length of the head 5 times and 1/2. The snout is broad and depressed; the interorbital space slightly convex, its width being nearly 1/2 of the head length. The upper lip is very thick, with three series of short broad papillae on its inferior half. The angle made by the two mandibulary bones is obtuse; the preorbital has an indistinct longitudinal ridge, and does not entirely cover the maxillary bone; its extremity is rounded, the anterior angle being not much wider than the posterior. Eyes without adipose membrane; nostrils close together, they are less distant from each other than the posterior is from the eye. The chin is entirely covered by the mandibularies, or they leave between them only a very narrow strip uncovered. There are 28 scales between the snout and the spinous dorsal. The two anterior dorsal spines exceed 1/2 the length of the head. There are 45 scales in the lateral line. The 13th, 14th or 15th, and the 26th or 27th scales of the lateral line correspond to the extremity of the pectoral and the origin of the two dorsal fins. The origin of the spinous dorsal is nearer to the caudal than to the snout. The root of the pectoral is somewhat above the middle of the body. The pelvic is inserted midway between the pectoral and the spinous dorsal.

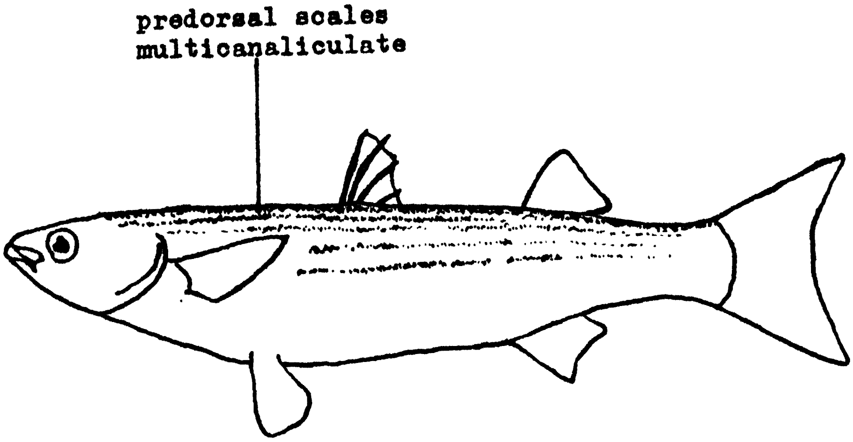
Color: Back and head bluish gray, belly silvery. Lateral lines of yellowish color along the sides.

This fish inhabits the Mediterranean Sea and enters into the lower reaches of the streams entering the Sea. A length up to 60 centimeters may be attained.

Liza saliens (Cuvier and Valenciennes)

The height of the body equals the length of the head and is contained 5 1/2 times in the total length. The snout is moderately broad, somewhat tapering anteriorly; the width of the interorbital space is 1/3 of the head length. The angle made by the two mandibulary bones is a right

Figure 89. Liza saliens



one; The preorbital does not entirely cover the maxillary. Eyes without adipose membrane. Nostrils close together, the posterior being in the middle between the orbit and the anterior. Lips not very thick, not covered by the nasal bones. The space at the chin, between the mandibularies and the interopercula, is elongate, tapering anteriorly. The two anterior dorsal spines are about half as long as the head. There are 45 scales in the lateral line. The pectoral terminates at some distance from the vertical from the origin of the dorsal, and its root is somewhat above the middle of the body.

Color: The back is generally dark gray, the belly silvery, with longitudinal lines of bluish cast.

This fish is found in the Mediterranean Sea and frequently is taken in the mouths of the streams entering it. A size up to 40 centimeters may be attained by this species.

Genus Mugil Linnaeus

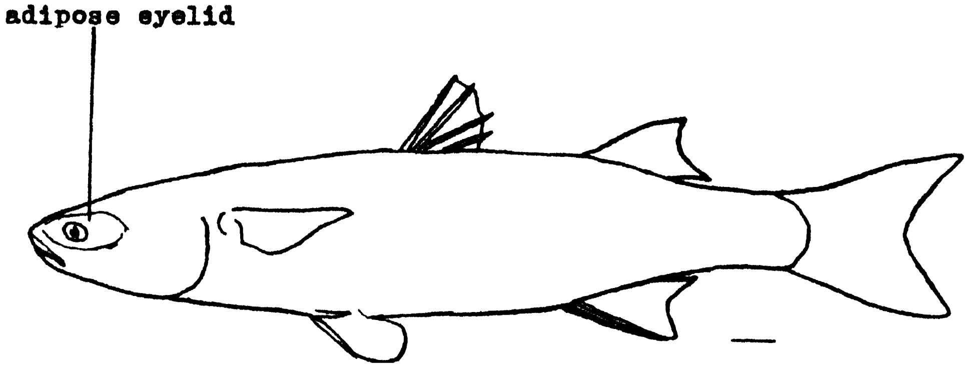
The mouth is more or less transverse, with the lateral cleft short. No true teeth in the jaws. The anterior margin of the mandible is sharp, sometimes ciliated. A division of the stomach is extremely muscular. Adipose eyelid well developed.

This genus is represented by one species in Syrian waters.

Mugil cephalus Linnaeus

The height of the body is contained 5 times in the total length, the head length 4 1/2 times. The head is very slightly convex superiorly, and the width of the interorbital space is contained two and one-third times in the head length. The upper lip is not thick. The angle made by the two mandibulary bones is obtuse. The cleft of the mouth is not quite half as deep as broad (between the angles of the mouth). The maxillary is entirely covered by the preorbital. Eyes hidden behind a broad adipose membrane. Nostrils rather distant from each other, the posterior being in the middle between the anterior and the orbit. The space at the chin

Figure 90. Mugil cephalus



between the mandibles is broadly lanceolate. The vertical fins are not scaly. The first two dorsal spines are half as long as the head. There are 42 scales in the lateral line. The pectoral extends to about the eighth scale of the lateral line, its base is above the middle of the body. The pelvic is inserted midway between the pectoral and the spinous dorsal.

Color: Back dark gray, belly silvery white, sometimes dark gray longitudinal lines are present.

This fish is found in the Mediterranean Sea and occasionally in the lower reaches of the streams emptying into the Mediterranean.

This fish may be raised in fresh water ponds. Young fingerlings are taken from the sea and brought to fresh water ponds. Young feed upon plankton and algae. Adults feed upon algal vegetation, debris and detritus. A length up to 50 centimeters may be attained, and a weight of about one kilogram. A fish 50 cms. long would be about 7 years old.

Family POECILIIDAE

Body oblong or moderately elongate, compressed behind, depressed forward, covered with large cycloid scales, which are adherent and regularly arranged. Head scaly, at least above. Mouth terminal, small, the lower jaw usually projecting; margin of upper jaw formed by the premaxillaries only; premaxillaries strong, extremely protractile. Teeth incisor-like or villiform, sometimes present on vomer, but usually in the jaws only; lower pharyngeals separate, with cardiform or rarely molar teeth; third upper pharyngeal enlarged, the fourth wanting or united to the third. Gill membranes somewhat connected, free from isthmus, gill rakers short, thick. Branchiostegals 4 to 6. Pseudobranchiae none. Dorsal fin single, inserted posteriorly, of soft rays only, rarely with a single spine or rudimentary spiny dorsal; caudal fin not forked; pelvic fins abdominal, rarely wanting; pectoral fins inserted low; no adipose fin. Stomach siphonal, without pyloric appendages. Air bladder simple, often wanting.

One genus represents this family in Syrian waters.

Genus Gambusia Poey

The body is moderately elongate, becoming deeper in the female. Mouth moderate, lower jaw projecting, the bones well joined; both jaws with a band of pointed teeth which are not movable. The snout is not produced. Scales large. Gill openings not restricted. Dorsal and anal fins both rather short and small, the anal more or less in advance of the dorsal; anal fin of male much advanced and modified into a long intromittent organ, which is about as long as the head. Intestinal canal short. Branchiostegals 6.

One species is represented in Syrian waters.

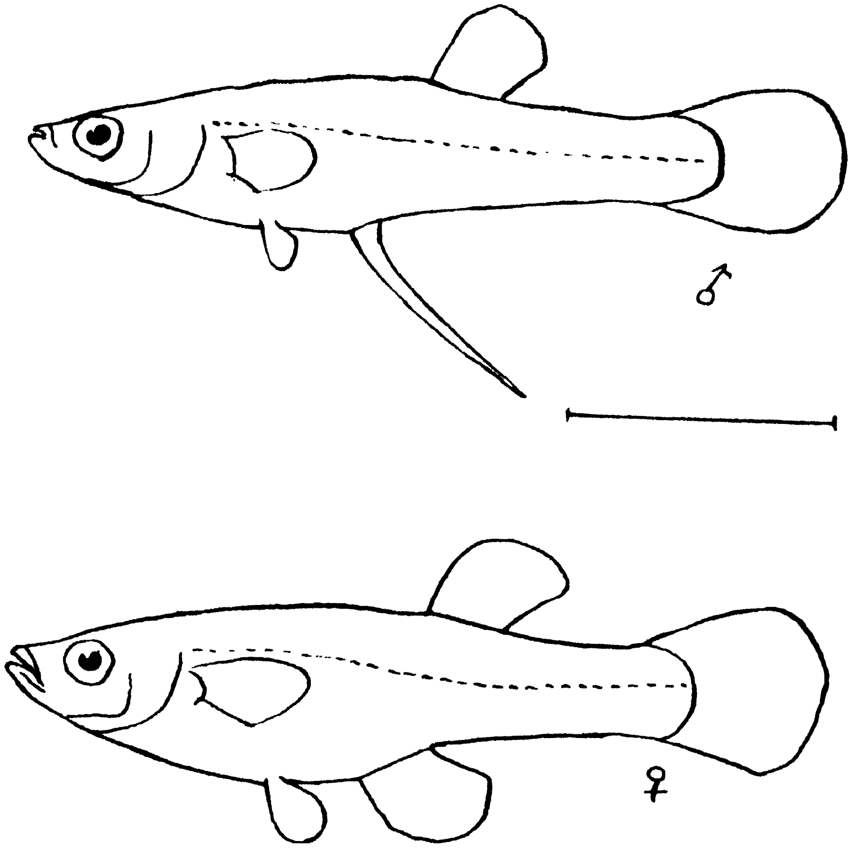
Gambusia affinis (Baird and Girard)

Head 3 1/4 to 4, depth 3 2/3 to 4 in standard length. Body rather plump, large specimens becoming deep. Head moderate, very broad and much depressed; teeth in broad villiform bands; eye moderate, 1 1/2 to 1 3/4 in interorbital width; 3 to 3 1/2 in head. Intestinal canal is long as body. Dorsal small, far back, distance from its insertion to caudal half that to its snout, its first ray about over middle of anal. Anal larger and higher than dorsal. Dorsal 6 to 8 rays, anal 8 to 10. Scales 29 to 32.

Color: Light olive, each scale edged with darker. A very narrow streak of dark along the sides. Top of head dusky. A more or less distinct triangular bluish black bar below eye. Sides and belly anteriorly dusty with dark dots. A black blotch on each side of the belly caused by the black internal organs showing through the skin. Young specimens often uniformly yellowish. Fins dusky, the caudal usually with a cross series of dots.

This species was taken from the lower Yarmuk River. It was introduced into the Jordan River drainage as a mosquito controller. It is quite effective as a mosquito controller since its primary food is small insect larvae.

Figure 91. *Gambusia affinis*



The species is a live-bearer, the young being born alive In warm waters several broods a year are possible.

The male is usually quite small, seldom attaining a length of 5 centimeters. The female grows to a larger size. Since this species is a warm-water fish, it will not become very widely distributed, probably thriving only in the lake Tiberias region.

Family SILURIDAE

Head and body naked, or covered with osseous scutes, but not scales. Mouth non-protractile, generally bordered by the premaxillaries and not the maxillaries, which are rudimentary and form the base for the maxillary barbel. Barbels always present, from one to four pairs. Suboperculum absent. Branchiostegals from 4 to 17 in number. No pseudobranchiae. Pharyngeals having small teeth, conical or in sheaths. Air bladder generally present, communicating with the organ of hearing by means of auditory ossicles. Adipose fin present or absent.

This family is represented in Syria by two genera.

Key to the Genera of Siluridae

1 a. Dorsal fin and anal fin very long .... Clarias
1 b. Dorsal fin very short, anal fin long .... Silurus

Genus Clarias Gronovius

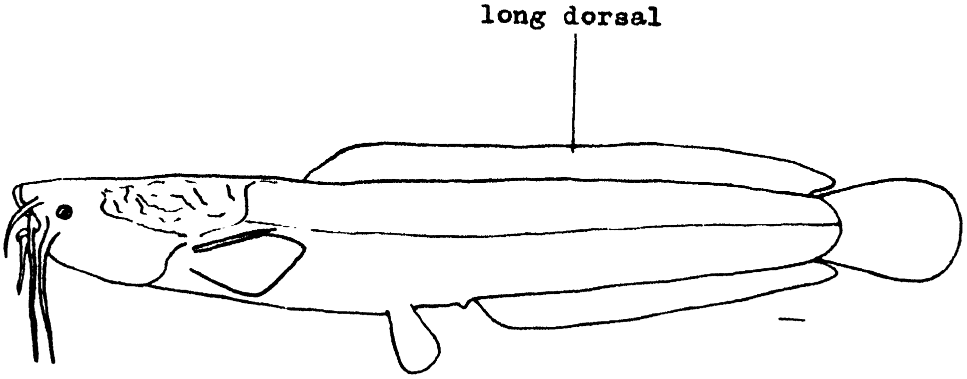
Adipose fin none. Dorsal fin long, extending from the neck to the caudal. Anal fin long. Jaws with a band of villiform teeth; a band of villiform teeth or granular teeth across the vomer. Cleft of the mouth transverse, anterior of moderate width. Barbels eight, one pair of nasal, one of maxillary, and two pairs of mandibulary barbels. Eyes small, with free orbital margin. The upper and lateral parts of tho head are osseous, or covered with a very thin skin. A dendritic, accessory branchial organ is attached to the convex side of the second and fourth branchial arches, and received in a cavity behind the gill cavity proper. Pelvic fins six rayed. Pectoral fin with pungent spine.

This genus is represented in Syrian waters by one species.

Clarias lazera (Cuvier and Valenciennes)

Depth of body 5 to 9 times in the total length, length of head 3 to 3 1/2 times. Head 1 1/2 to 1 2/3 times as long as broad, its upper surface coarsely granulate in the adult; occipital process angular and rounded; frontal fontanelle sole-shaped or knife-shaped, 2 1/2 to 4 times as long as broad, 3 1/2 to 6 times in head length. Occipital fontanelle small, in advance of occipital process. Eye 2 (young) to 4 1/3 times in snout length, 4 to 7 times in interorbital width. Width of mouth equal to or a little less than interorbital width. Band of premaxillary teeth 4 (young) to 6 times as long as broad. Vomerine teeth granular, forming a crescentic band with or without a posterior median process, its greatest width in the middle 1 1/2 to 2 1/2 times that of the premaxillary band; anterior mandibular teeth pointed, posterior granular. Nasal barbel 1/3 to 2/3 length of the head (up to 4/5 in very young). Maxillary barbel usually a little shorter than the head, sometimes a little longer (up to 1 1/2 in very young), reaching extremity of pectoral spine or a little beyond extremity of pectoral fin. Outer mandibular barbel 1 1/5 to 1 2/3 times as long as inner, which measures 2/5 to 3/5 head length. Gill rakers long and close set, 35 (very young) to 135 on anterior arch. Clavicles striated or rugose with granulations, more or less distinct under thin skin. Dorsal 62-82 rays, its distance from occipital process 1/7 to 1/4 head length, its distance from the caudal not greater than the eye diameter. Anal 50-65 rays, narrowly separated from caudal. Pectoral 2/5 to 1/2 head length, the spine serrated on the outer side, and 2/5 (young) to 3/4 the length of the fin. Pelvics equally distant from end of snout and root of caudal, or a little nearer the snout. Caudal about half length of head.

Figure 92. Clarias lazera



Color: Greyish olive to olive brown to blackish above, uniform or marbled with lighter; white or greyish underneath. Vertical fins often with yellowish edge; usually more or less distinct dark band on each side of the lower surface of the head. Young specimens often with a dark bar, edged with yellowish in front and behind, across the caudal fin; black spots sometimes present on the caudal fin.

This fish is found in Lake Tiberias, Lake Homs, and the Orontes River. It is predatory in habit. It may attain a length of 1 meter. The Sallour, as it is called locally, has been one of the primary commercial species, being taken in large quantities, up to 700 tons per year, from the waters of the el Ghab.

Genus Silurus Linnaeus

Body rather elongate, rounded anteriorly, compressed on the sides. Head naked, depressed. Three pairs of barbels, one maxillary, two on the mandible. Nostrils well separated. Mouth large, terminal. Teeth in cards on the jaws and vomer; palatines not toothed. One dorsal fin, very short, without pungent spine. No adipose fin. Anal fin very long, united with caudal. Pectoral armed with a strong spine, toothed. Pelvics behind the dorsal, and composed of 8 rays. Caudal rounded. Eye situated above level of the angle of the mouth.

This genus is represented by two species in Syrian waters.

Key to the Species of Silurus

1 a. Maxillary barbel much longer than head .... S. glanis
1 b. Maxillary barbel reaching end of head .... S. triostegus

Silurus glanis Linnaeus

The height of the body is contained 6 1/2 to 7 1/2 times in the standard length, the head length 5 to 6 times. The eye diameter is contained 10 - 13 times in the head length. The mouth is a large slit, horizontal, and reaches behind nearly under the anterior edge of the eye. The maxillary barbel considerably longer than head; the mandible barbels very short, especially the anteriors. The mandible is protruding. The lateral line approaches the back closer than the belly and is straight. The dorsal, situated over the space between the pectoral and the ventral, is 2 2/3 times as near the snout than the origin of the caudal, its longest ray is about 1/4 the head length. The anal is nearly united with the caudal. The pectoral is rounded, and measures 1/2 to 3/5 the length of the head and does not attain the pelvic. The pectoral spine is indistinctly serrated. The pelvic is equally rounded, is 2/3 the pectoral, and passes the origin of the anal. The caudal is rounded.

Color: Brown olive or greenish on the back, grayish yellow on the sides, whitish on the belly. It frequently has marblings of brown, greenish, or darker gray on the sides, especially in large specimens. The fins are brownish.

This fish is found in the Euphrates River. It attains a length over 2 meters and a weight of over 150 kilograms. It is a predatory species. It is a valuable food fish. It spawns in April, May or June. The eggs are quite small, reaching a diameter of 3 millimeters.

Silurus triostegus Heckel

The lower jaw is prominent. The length of the head is contained 5 1/4 times in the total length. The maxillary barbels reach to the end, the mandibular barbels to the middle of the head. Pectoral spine serrated. Anal and caudal fins confluent.

This fish was taken from Lake Khatuniyeh, and generally follows the pattern of Silurus glanis.

Figure 93. Silurus glanis

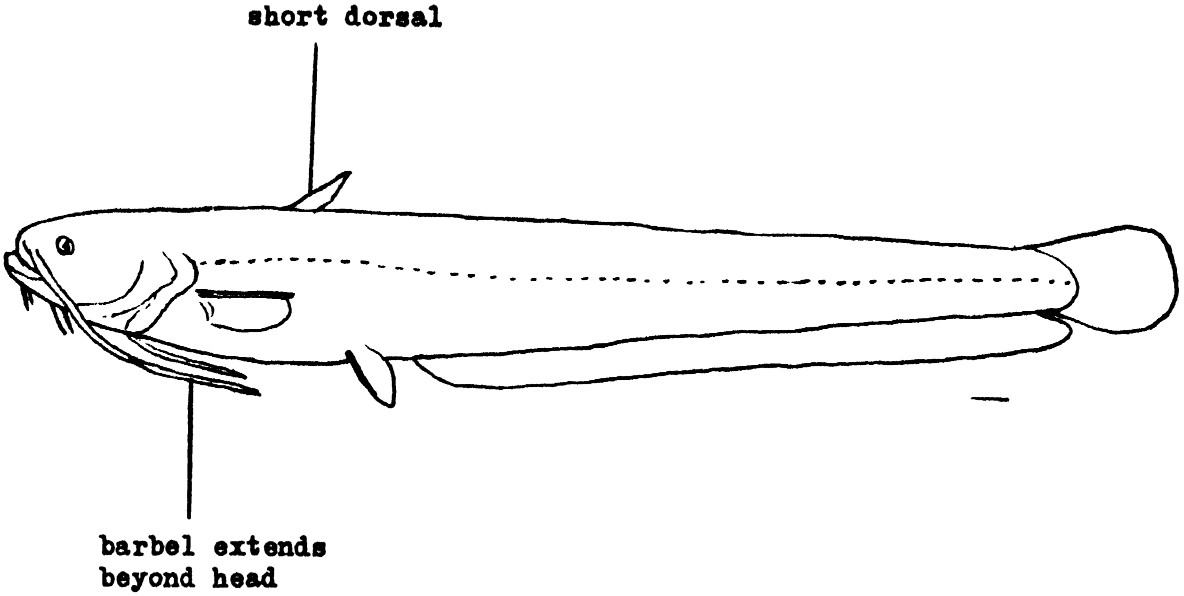
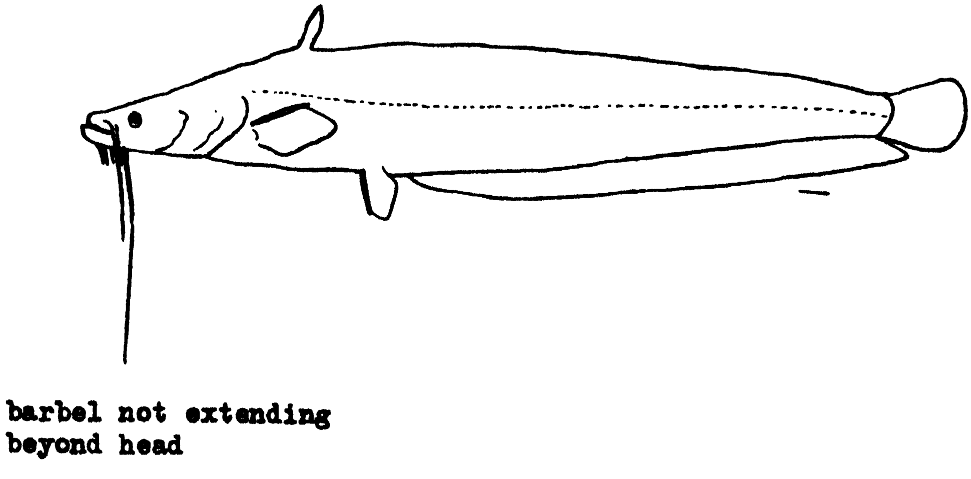


Figure 94. Silurus triostegus



Family SISORIDAE

Dorsal fin short, placed anteriorly on trunk in advance of the pelvics; adipose well developed, moderate length; anal fin short. Gill membranes not confluent with skin of the isthmus, with posterior margin free. The anterior and posterior nostrils are close together with a barbel between.

This family is represented by one genus in Syrian waters.

Genus Glyptothorax Blyth

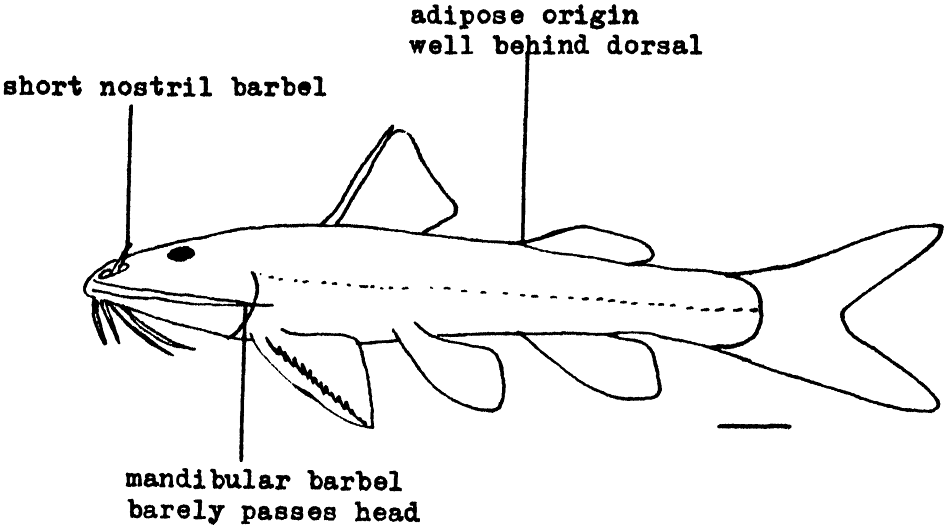
Adipose of moderate length; a short dorsal fin with a pungent spine and six soft rays; anal fin short. Barbels 8. Teeth on palate villiform, in two separate patches. The upper jaw longer than the lower. Eyes small, below the skin. Caudal fin forked; pelvic rays 6. Pectorals horizontal, with a thoracic adhesive apparatus between, which is formed by longitudinal plaits of the skin.

This genus is represented by one species in Syrian waters.

Glyptothorax cous (Linnaeus)

Head rather broad, depressed, with the snout elongate and with the upper jaw projecting beyond lower. Eye very small, situated behind the middle of the length of the head, directed upwards. Numerous minute osseous striae on the upper surface of the head, extending back to dorsal origin, and also onto forward edge of the pectoral fin. Nostrils rounded, close together, with a barbel between, which is one-fourth the head length; maxillary barbels broad at the base, as long as or slightly shorter than head; a small elliptical patch of teeth on each side of the palate, shorter than space between patches. Dorsal spine stout, non-serrated, as long as from tip of snout to back of eye; pectoral spine strong, with recurved spines along its inner edge, more than half as long as head. Adipose fin longer than dorsal. Dorsal rays I, 6; Anal rays 11, 8 branched; pelvic rays 6, 5 branched.

Figure 95. Glyptothorax cous



Color: Upper body and sides brownish, somewhat mottled with lighter yellowish, lower belly yellowish. Broad blackish band on base of caudal fin, and along forward edge of pectoral; a faint blackish band on dorsal. Whitish osseous striae on head.

This fish was collected from the Euphrates River. It is also reported from the Kueik River, but no specimens were taken in the collections made there. This fish was described in a book by Russell on the Natural History of Aleppo in 1756. Nothing is known of its life history.

Provisional List of the Freshwater Fishes of Syria

1. Family ANGUILLIDAE
   1. Genus *Anguilla* Shaw
      1. *A*. *anguilla* (Linnaeus)
2. Family BAGRIDAE
   1. Genus Mystus Scopoli
      1. *M*. *pelusius* (Solander)
3. Family BLENNIDAE
   1. Genus *Blennius* Linnaeus
      1. *B*. *vulgaris* Pollini
4. Family CICHLIDAE
   1. Genus Haplochromis Hilgendorf
      1. *H*. *flavi-josephi* (Lortet)
   2. Genus *Tilapia* A. Smith
      1. *T*. *galilaea* (Artedi)
      2. *T*. *nilotica* (Linnaeus)
      3. *T*. *zilli* (Gervais)
   3. Genus *Tristramella* Trewavas
      1. *T*. *sacra* (Gunther)
      2. *T*. *simonis* *magdalenae* (Lortet)
      3. *T*. *simonis* *simonis* (Gunther)

5. Family COBITIDAE
    1. Genus *Cobitis* Linnaeus
        1. C. ___?___
        2. *C. taenia* Linnaeus
    2. Genus *Nemachilus* Hasseltine
        1. *N. argyrogramma* (Heckel)
        2. *N. frenata* (Heckel)
        3. *N. galilaeus* (Gunther)
        4. *N. insignis* (Heckel)
        5. *N. panthera* (Heckel)
        6. *N. tigris* (Heckel)

6. Family CYPRINIDAE
    1. Genus *Acanthobrama* Heckel
        1. *A. centisquama* (Heckel)
        2. *A. lissneri* Tortonese
        3. *A. marmid* Heckel
        4. *A. terrae-sanctae* Steinitz
    2. Genus *Alburnus* Heckel
        1. *A. caeruleus* Heckel
        2. *A. capito* Heckel
        3. *A. mossulensis* Heckel
        4. *A. orontis* Sauvage
        5. *A. pallidus* Heckel
        6. *A. sellal* Heckel
    3. Genus *Aspius* Aggassiz
        1. *A. vorax* Heckel
    4. Genus *Barbus* Cuvier
        1. *B. barbulus* Heckel
        2. *B. canis* Cuvier and Valenciennes
        3. *B. chantrei* Sauvage
        4. *B. esocinus* (Heckel)

   5. *B. grypus* Heckel
   6. *B. kersin* Heckel
   7. *B. lacerta* Heckel
   8. *B. longiceps* Cuvier and Valenciennes
   9. *B. lorteti* Sauvage
   10. *B. luteus* (Heckel)
   11. *B. orontis* Sauvage
   12. *B. pectoralis* Heckel
   13. *B. rajanorum* Heckel
   14. *B. scincus* Heckel
   15. *B. sharpeyi* Gunther
   16. *B. subquincuniatus* Gunther
   17. *B. xanthopterus* (Heckel)

5. Genus *Barilius* Ham. Buchanan
   1. *B. mesopotamicus* Berg

6. Genus *Chondrostoma* Agassiz
   1. *C. regius* Heckel

7. Genus *Cyprinion* Heckel
   1. *C. kais* Heckel
   2. *C. macrostomus* (Heckel)

8. Genus *Cyprinus* Linnaeus
   1. *C. carpio* Linnaeus

9. Genus *Garra* Ham.Buchanan
   1. *G. lamta* (Buchanan)
   2. *G. rufus* (Heckel)
   3. *G. variabilis* (Heckel)

10. Genus *Leuciscus* Klein
    1. *L. cephalus orientalis* (Nordmann)
    2. *L. lepidus* (Heckel)
    3. *L. spurius* (Heckel)

11. Genus *Phoxinellus* Heckel
    1. *P. drusensis* Pellegrin
    2. *P. kervellei* Pellegrin
    3. *P. libani* Lortet
    4. *P. rutiloides* Tortonese
    5. *P. syriacus* (Lortet)
    6. *P. zeregi* Heckel

12. Genus *Rutilus* Rafinesque
    1. *R. tricolor* (Lortet)

13. Genus *Tylognathus* Heckel
    1. *T. nanus* Heckel

14. Genus *Varicorhinus* Ruppell
    1. *V. barroisi* (Lortet)
    2. *V. damascinus* (Cuvier and Valenciennes)
    3. *V. syriaca* (Cuvier and Valenciennes)
    4. *V. trutta* (Heckel)
    5. *V. umbla* Heckel

7. Family CYPRINODONTIDAE
    1. Genus *Aphanius* Nardo
        1. *A. dispar* (Ruppell)
        2. *A. mento* (Heckel)
        3. *A. sophiae* (Heckel)

8. Family GASTEROSTEIDAE
    1. Genus Gasterosteus Linnaeus
        1. G. argyropomus Cuvier and Valenciennes

9. Family MASTACEMBELIDAE
    1. Genus Mastacembelus Gronovius
        1. M. mastacembelus Solander

10. Family MUGILIDAE
    1. Genus Liza Jordan and Swain
        1. L. abu Heckel
        2. L. auratus (Cuvier)
        3. L. capito (Cuvier)
        4. L. labrosus (Risso)
        5. L. saliens (Cuvier and Valenciennes)
    2. Genus Mugil Linnaeus
        1. M. cephalus Linnaeus

11. Family POECILIIDAE
    1. Genus Gambusia Poey
        1. G. affinis (Baird and Girard)

12. Family SILURIDAE
    1. Genus Clarias Gronovius
        1. C. lazera (Cuvier and Valenciennes)
    2. Genus Silurus Linnaeus
        1. S. glanis Linnaeus
        2. S. triostegus Heckel

13. Family SISORIDAE
    1. Genus Glyptothorax Blyth
        1. G. cous (Linnaeus)

Families	13
Genera	31
Species	86

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Chapter III

The Freshwater Environment

Now that we have studied the structure of a fish and how the species can be identified, let us turn our attention to the places where these fishes live. A knowledge of the places where fish can and do live is essential if we are to do anything about getting more fish from these waters.

Water is the most abundant liquid on earth. Upon it depends all life. Where water is plentiful, the forms of life are many, but as water becomes scarcer the living organisms become fewer and fewer, until in the total absence of water, life ceases.

Water is called the universal solvent, because it dissolves more substances than any other liquid. When water first reaches the earth, usually as rain or snow, it is almost pure. It has dissolved only very small amounts of materials as it passed through the atmosphere. But once it reaches the earth, it immediately begins dissolving materials as it gathers to flow in streams and rivers into lakes and oceans.

The total water mass of the world makes up about 5/6 of our planet. The study of this mass is called Hydrography. Hydrography is further divided into two branches -- Oceanography, the study of the oceans, and Limnology, the study of the inland waters. We shall confine our study here to the study of the Inland waters.

Freshwaters may be divided into two major groups -- Standing or Lentic waters, and Running or Lotic waters. Standing waters may be called lakes, ponds, pools, marshes, swamps or bogs. Lakes are generally permanent bodies of water, occupying a definite basin, and have a barren, wave-swept shoreline. Lakes are formed in many ways, and are of a great many sizes and shapes. Many were formed by the action of ice sheets which covered the northern areas of the world in time past. As the huge icesheets moved southwards, holes were dug into the ground, and when the ice melted, deposits of stone and sand occurred and these formed ridges behind which lakes formed. In other places, big chunks of ice were buried, and these melted leaving huge holes to fill up with water.

Lakes are caused in some mountain areas by landslides blocking off river beds, much as man today builds huge dams to create lakes. Others are formed by the dissolving of underground rock, such as limestone, and these holes fill up with water. Then the movements of the earth's crust, as in earthquakes, has created many lakes. The Dead Sea and Lake Tanganyika are examples of this type. Sometimes after a volcano has died out, the crater it left becomes filled with water and we have a lake. Then along big rivers, such as along the Euphrates, lakes are created by the river making a new channel across a narrow neck of land, leaving the old bend as a lake, known as an oxbow. And sometimes along the shore of the oceans, the earth is piled up in a manner to cut off part of the sea to form a lagoon behind this wall. Sometimes these lagoons may become freshwater lagoons if it should happen to be in areas of heavy rainfall or happen where a freshwater stream may enter the lagoon.

A pond varies in size and shape also. Generally a pond is described as a small body of water of shallow depth with much emergent vegetation. The determination of when a pond is a pond and a lake a lake is often difficult. There are several definitions and classifications, but no common agreement at the present time. Thus what may be called a pond under one system may be called a lake under another and vice versa.

A pool is usually considered to be a temporary body of water, a small area of water which goes dry each year. This type of pool is not to be confused with the pool designation for streams.

Marsh, swamp, and bog are names applied in various places to the same type of wet area. This area is usually a low piece of ground which sometimes has standing water on it, but at other times may only have water in the soil itself, but remains very soft and wet and spongy. It is difficult to walk in because one sinks into the loose wet ground. A marsh, swamp, or bog is almost entirely covered with vegetation, only small areas remaining in open water, if at all.

All lakes must be considered as temporary bodies of water because in time all will fill up with silt and dirt. Water entering the lakes, such as rivers, or just rainwater flowing off the surrounding lands brings in soil and trash to commence the process of filling up. Then the winds blow sand and dirt into the lakes, and within the lake itself the process of filling up takes place through erosion. Winds cause waves and the waves wash the shores or banks and cause them to erode and fall into the lake. Also the outlet river cuts farther and farther down into the earth, thus draining more water from the lake. Within the lake, another process takes place in the growing of animals and plants and their subsequent dying and decaying to form detritus which tends to fill up the basin. Eventually the lakes become ponds. The process of filling then becomes more rapid with more vegetation until the pond finally becomes a marsh. Then the process of filling becomes even more rapid, and the final result becomes dry land. Marshes are often deliberately drained to create new land for agriculture. A good example of this is the drainage of the el Ghab marsh, where the river was deepened to permit the water to run off, and extra drains were dug to remove excess standing water.

Running or Lotic waters may also be divided into several types. The first and smallest is usually called a rivulet. After rain falls or snow melts, the drops of water gradually flow together until they form a small trickle of water, the rivulet. Several rivulets flow together to form a brook or creek. A brook is a swift flowing stream, and has little accumulation of silt or detritus on the bottom. A creek is a slow flowing stream and thereby has a muddy bottom. When several brooks or creeks join together, a river is formed. The exact division between creeks or brooks and a river is difficult to specify, since from the tiniest rivulet to the largest flowing river one can find every intermediate gradation. However, not all brooks, creeks or rivers follow this pattern. Some creeks, brooks and rivers are formed from springs, or as outlets from lakes and ponds.

There are three main phases in the study of inland waters -- 1. the study of the physical characteristics; 2. the study of the chemical characteristics; and 3. the study of the biological characteristics. Actually, it is very difficult to separate these three phases since they are so greatly interwoven. Many chemical properties are dependent upon the physical conditions and vice versa, and the biological conditions are dependent upon both and influence both. The physical factors are determined by the materials held in suspension, or in solution in the water, by its depth, temperature, movement, illumination, shore and bottom types. The chemical factors are found in acidity or alkalinity of the water, and in the gases, salts and other material in it. The biological productivity of the water depends upon both the physical and chemical characteristics, as well as on the biology of the organisms inhabiting the water.

Let us start first with some of the physical characteristics of the water. Pure water is a colorless liquid, yet when we look at water we see many shades of color. This is due to two factors. One is true color and is due to substances dissolved in the water. For example, water from a marsh may be brown due to material dissolved in it. Even on straining through the finest filters, the color is still brown. Other colors in the water may be apparent color. Blue water of lakes is due to the reflection of the sky. Other waters may be reddish due to the carrying of fine particles of red clay or silt. This red color disappears upon filtering because the red clay particles were in suspension in the water and not dissolved in it. Sometimes plankton becomes so abundant that it may give color to the water. Color of water may have a major role in production by hindering light penetration.

Turbidity also has an influence on biological productivity and is caused by materials in suspension in the water, such as the particles of red clay just mentioned as giving color to the water. Other things, too, can cause turbidity besides inorganic soil particles. Small plants and animals growing in the water can also affect the turbidity. At times certain plants and animals become so abundant that they stop almost all of the light from penetrating the water, as well as give an apparent color to it. In determining turbidity several instruments may be used. One of the most common is the Secchi disk, a metal plate about 20 centimeters in diameter and painted black and white in alternate quarters. This disk is lowered horizontally on a rope into the lake and the depth at which it disappears is recorded. Then the disk is slowly raised until it reappears in sight and this depth is recorded. The average of these two readings is taken as the depth of light penetration. Generally these measurements are taken in midday light. Light does penetrate deeper than is recorded by this method, and the amount of light is determined very accurately by use of photoelectric cells or photographic plates. The amount of light penetrating the water influences the amount of vegetation growing in the lake or stream.

Water is mobile. It has no definite shape and thus flows into and conforms to all contours. It does have internal friction as well as friction against the bottom and sides of the lake or stream. When water becomes cool it becomes less fluid and as it warms it becomes more mobile. This stiffening has an influence on plants and animals and their movements.

Water is 773 times denser than air and its buoyancy is greater also. Most animals living in the water have a density nearly that of the water, which permits them to swim or float very easily.

Pressure of water increases with depth. At the bottom of the deep lakes this pressure is very great, and organisms living in the great depths must make proper adjustments to this pressure by changes in form or by special adaptations.

Depth has an influence on the circulation of water in lakes and on the flowing of water in streams, and the amount of materials carried by the streams.

Current has a major role as a physical factor. In lakes, there are several currents. One is the vertical current due to heating and cooling of the water. Another current in lakes is horizontal and is due to winds or tides. In very shallow lakes this usually involves the whole basin, but in deep lakes may involve only a surface layer. Returning currents are called undertows.

In streams, currents are generally horizontal and depend upon the shape and slope of the river bed -- a steep slope, a swift current. The type of bottom also has an influence on the flow. A smooth, hard bottom permits an increase in current, while a rough, or soft bottom will tend to slow the current. The current determines the amount of material carried in the stream. A fast current can carry many particles along, while a slow current cannot. Thus we find deltas and the filling in of pools where currents slow down. First the large particles are dropped, then smaller and smaller ones.

The type of bottom in lakes and streams has an influence on the production of organisms. A very easily moved bottom of soft mud does not permit the growth of many food organisms because it continually moves and covers them. Similarly on sandy, waveswept beaches, the food organisms are scarce because of the continuous movement of shifting sands.

Temperature is another physical factor which has a great influence on the chemical and biological conditions of a body of water. Water is a peculiar fluid which reaches its maximum density at a temperature of 4° Celsius. At temperatures above and below this, the density becomes less. This is very important especially in cold regions where freezing temperatures occur for periods of time each year. If water continued to increase in density as it became colder, ice would form at the bottom of lakes and in many regions ice would remain at the bottom all year round, or as is found in arctic regions now where the water freezes to the bottom each winter, only a thin layer of water appears on the surface of the ice each year during the summer, and no fish life is possible. However, since it does become lighter, ice melts each year in all except the coldest ice cap areas.

This effect of water becoming lighter on warming or cooling above and below 4° C. causes a circulation of water in lakes. Water in lakes is heated from the surface and only by convection currents does the lower water become heated. In shallow lakes wind action causes circulation and shallow lakes are usually quite uniform in temperature. But in deep lakes, 10 meters or more, a layering takes place. There are three zones formed by this layering: the Epilimnion or surface zone of more or less uniform temperature; the Thermocline, a zone in which the temperature drops suddenly and at least 1° C. per meter increase in depth; and the bottom layer or Hypolimnion in which the temperature is again more nearly uniform, with changes of less than 1° C. per meter increase in depth. Since none of the Syrian lakes are in this deep category, we will not need to discuss this situation further.

Temperature does affect the chemical content in that the hotter the temperature, the more of some chemicals it can dissolve, and the less oxygen it will contain. Just at freezing the water holds the most oxygen or 14.62 parts per million, while at 20° C, the water holds only 9.17 parts per million.

Sinde most of the freshwater animals are cold-blooded, the temperature has a great effect on their movement. The colder the water the less activity, although excessively high temperatures will also reduce their activity. With the normal temperature limits, the cold-blooded animals double their metabolic rate for each 10° C. rise in temperature.

The chemical characteristics of the water involve the gases dissolved in it, the inorganic salts, the acidity or alkalinity and the organic matter. All life in the water depends on the substances in solution or suspension for existence. All gases in the air dissolve in water in regular proportions and of these oxygen and carbon dioxide are the most important. The animals use the oxygen and give off carbon dioxide, while the plants during daylight hours use the carbon dioxide and manufacture carbohydrates giving off oxygen as a by-product. During the hours of darkness, the plants also use the oxygen dissolved in the water to maintain life. In some ponds where there is an excess of plant life during the hours of darkness, it frequently happens that all the oxygen may be used up and many of the animals and plants die from lack of oxygen.

Thus in addition to dissolving oxygen and carbon dioxide from the air, we see that these gases may be manufactured within the lake by the plants and animals. Carbon dioxide may also be derived from the decomposition of plant and animal material in the water and bottom soils.

Nitrogen for plant use comes from the nitrates formed in the water. Green plants use it to form proteins. These nitrates are usually formed by bacteria in the decomposition of organic matter following the nitrogen cycle.

Carbonates are formed in the water with the carbon dioxide forming combinations with sodium, calcium, potassium,and magnesium. Plants can use some of these carbonate salts to supply needed carbon dioxide for photosynthesis should free carbon dioxide be unavailable. Sometimes these carbonate salts can be seen in accumulation on plants. They also form shells of snails and clams, and may even be deposited so heavily as to form a particular type of bottom soil called marl.

Sulfates, phosphates, chlorides, etc. are also present uniting with the sodium, potassium, calcium, magnesium, etc. to form various salts. Some of these salts may be so abundant as to be harmful to plant and animal life.

Methane, hydrogen sulfide, ammonia, and other gases may be present at times and places, but again need not be discussed here.

Acidity and alkalinity are important chemical factors. These items are measured by the concentration of the hydrogenions in the water and are expressed as pH. A pH of 7 is neutral. Figures less than 7 are representative of the acid side and those above 7 are on the alkaline side. For most abundant life in the waters, a slightly alkaline condition is best. Conditions of excessive acidity or alkalinity result in loss of life. This is generally true of all chemical compounds and elements in the water. Excess oxygen, for example, will kill fish just as too much salt or acid will.

The biological characteristics are of two major kinds: 1. those factors which act from within the animal itself, such as structure, function, toleration, nutrition, growth, reproduction, respiration, excretion and behavior; and 2. those factors which act from without, such as the relationship between plants and other animals, competition, predation, and pollution. These biological characteristics will be discussed in detail in the following chapters.

Chapter IV

Reproduction and Early Development

A knowledge of the reproductive habits of fishes is essential to the fishery biologist and fish culturist if they are to make any progress in their activities. It is important to know how many eggs an adult female of a particular species can lay at one time if one is holding a stock of fish for breeding purposes in a hatchery. The fish culturist must know how many females to keep in order to have an adequate supply of young for the ponds. It is also important to know when the fish spawn in the wild as well as where they spawn so that they may be protected if need be to insure future supplies. The age or size at which the fish becomes mature is also of great consequence in maintaining an adequate population.

The spawning of fishes is almost as varied as there are kinds of fish. Spawning varies according to individuals, species, climate, elevation, latitude, and bathymetric distribution. Some fishes spawn in the spring or summer, others spawn in the fall or winter. Those spawning in the spring or summer appear to be influenced by the rising temperature of the water and the increasing amount of light. Those spawning in the fall or winter respond to the opposite effects. It is not known whether light or temperature plays the bigger role, but both are important factors. Some tropical species spawn at intervals throughout the whole year without influence from light or temperature. Some spawn when a few weeks old, while other species may require many years to reach maturity.

Basically there are two major systems of reproduction in fishes: 1. Live-bearing or Viviparous, and 2. Egg-laying or Oviparous. Fishes having the livebearing form of reproduction are represented in Syria by the Gambusia which were introduced to control malaria. We will briefly review this form of reproduction before proceeding to the common form.

Livebearing is divided into two types also. The first is the more common and is the internal development without nourishment from the mother. The yolk of the egg supplies all the food for the development of the young fry. Fertilization is internal and the young are born alive, ready to take care of themselves. The second type of livebearing is found only in a few primitive sharks and is very similar to development in higher vertebrates in that the embryo receives nourishment from the mother through a placenta-like organ.

Egg-laying or Oviparous system of reproduction is found in the vast majority of fish species. All but one type of fishes found in Syria belong to this system. The eggs are deposited into the water by the female and are fertilized by the male in the water outside the body of the female. There may be just one male per female, or there may be a group of males for each female, or there may be a community of males and females occupying a spawning area all shedding their sex products at the same time. The spawning position of fishes varies tremendously also. They may spawn belly down, belly up, or on one side or the other. Spawning may take place in the bottom, on the bottom, or anywhere from the bottom to the surface. It may occur on mud, sand, gravel or rubble bottoms, in weeds or in specially prepared nests. Fishes exhibit all degrees of parental care. The amount of parental care is inversely proportional to the number of eggs laid, the larger the number of eggs laid the less care. In general parental care is better developed in freshwater fishes than in the marine species. There are several general groupings that may be made in the care given by the parents to their eggs and young.

In one group we can put those parents who do nothing to aid the survival of their young, but just scatter their eggs while spawning. Some of these scattered eggs are floating eggs which contain oil droplets for buoyancy. These are found only in the marine species such as the cod and eel. No freshwater species is known to have floating eggs. Other fish in this group have eggs which sink to the bottom and lodge among the stones or sand, as in some Barbus. Others have eggs which are sticky and they adhere to plants, debris, or stones, and are not easily dislodged.

In the second group the eggs are scattered, or laid individually, but some provision is made for protection although there is no parental care after laying. In this group we find fish, like the yellow perch, that lay their eggs in long gelatinous strings, winding the string amongst the aquatic vegetation or other debris, like fallen trees. Also in this group are found fish with eggs that have coverings which may be stalk-like, or may be in capsules which are fastened to vegetation or float loosely, as found in some sharks. Other fish, such as the smelt and flying fish, have eggs with a membrane which ruptures upon entering the water and this membrane becomes an organ by which the egg adheres to vegetation or stones. Some rays bury their eggs in capsules in the sand of the ocean bottom.

A third group of fishes is the one in which fish lay eggs in masses of jelly, but not in constructed nests. Generally in this group the eggs are guarded after they are laid and usually it is the male that does the guarding. An example of this type is found in a marine fish called the lump sucker, whose eggs are laid in rock crevices above low water level of the spring tides. From 80,000 to 136,000 eggs are laid in one jelly mass. The eggs are exposed by the very low spring tide, but the male remains on guard, remaining with the eggs even though it may cost him his life. The eggs and male fish are subject to severe predation by gulls and other sea birds as well as by other animals that may frequent the beaches. If the eggs should be washed high up on the beach during a storm, the male will wander about on the beach searching for the lost eggs.

Another group of fishes in the classification of parental care are those fishes who construct nests in the bottom soils for the deposition of eggs. In this group are found the trout, who construct redds in the bottom gravels. The female digs with her body a depression or groove in the bottom gravel and after spawning covers the eggs with gravel again. Other fish like the log perch will burrow into the bottom and deposit their eggs and then the bottom materials settle back into the depression as the body is withdrawn. Some of the basses and other fish make cup-shaped or saucer-shaped depressions in the bottom by pushing the bottom soils aside with their tails. The eggs are laid in the depression and the male remains on guard to protect the eggs and fry. Some catfish will burrow into the mud or detritus bottom and make a hollow or burrow into the banks of the stream and make a nest, and then remain on guard to protect them and the young fry after hatching.

The fifth group of fishes are those like some minnows and cottids which lay their eggs under objects or on objects in the water. Some lay their eggs under boards, tile or flat stones. Some may lay their eggs in cracks between pilings supporting docks or dams. The male usually stays nearby to drive off other fish or animals which would prey upon their eggs or young.

Another group are those who construct elaborate nests of vegetation. In Syria, the little stickleback, Gasterosteus, will build such a nest. Mucous secretion from the body is used to stick pieces of vegetation together to form a nest much like a birds nest. Spawning takes place within the nest and the male guards the entrance.

A seventh grouping in parental care includes mainly tropical fish who build their nests of bubbles. The Trichogaster of Indonesia builds such a nest by blowing bubbles of a mucous secretion around the eggs and making a collection of bubbles among the floating vegetation of the surface. The eggs are lighter than water and the male turns the female belly up as they spawn. He picks the eggs one at a time up in his mouth and makes the bubble and puts it in the nest.

The eighth group contains a variety of fish with special adaptations for care of eggs by the parents. First among this group we have some of the Tilapia and Tristramella of Syria. The eggs are picked up by the mother and carried around in her mouth until they hatch, and after hatching when danger approaches, the fry seek shelter once again in the mother's mouth. Another peculiar development is the pouch of the sea horse. A pouch is developed on the abdomen of the male and the eggs after spawning and fertilization are placed in this pouch for development.

Another especially odd adaptation is in the Indo-Pacific genus Kurtis, where the male develops a bony hook on his forehead and the eggs are laid in two masses connected by a gelatinous string. The string is hooked over the bony hook on the male's head and he carries the eggs around with the two masses of eggs hanging on each side of his head.

A species of South American catfish develops a very soft spongy pad on the belly. When the eggs are laid the female presses down upon them and they are imbedded into this spongy pad and are carried about until they hatch. Following hatching, the pad disappears and the belly skin returns to a normal condition.

There are many, many more odd types, but space does not allow us to continue describing them. The last group of special adaptation is to be found in some species like the European bitterling, a small minnow. It deposits its eggs in clams. The female has a long ovipositor which is inserted into the valves of the clam and the eggs are laid. The circulation of the water by the clam aerates the eggs and they are completely protected by the clam shell from any predation. This, however, is not the complete story. It is a case of mutual assistance, for at the same time the fish is laying its eggs, the clam is shedding its young, known as glochidia, and these glochidia must be attached to a fish to develop. They are parasitic during their early stage of development. Thus with the fish coming to lay eggs in the clam, the clam is assured a place for its young to attach themselves to develop.

The size of eggs varies as does the number of eggs with each species, and with the size of the individual as well. Eggs vary in size from about one-half millimeter in diameter to as large as 125 millimeters. In numbers the counts have been determined from as few as 10 eggs to over 150 million. In a later chapter on Field and Laboratory Techniques, the methods for determining the number of eggs per female are described.

Generally it is characteristic of fishes that the two sexes are separate, but there are a few species that are hermaphroditic, and it is also reported that some of these hermaphroditic forms are even self fertilizing. It is very difficult to tell the sex of fish in the very young stages without dissection. However, even after the fish reaches sexual maturity it is difficult to distinguish the sexes. In those species where separation is possible, the males are generally the brighter colored. Usually during the breeding season it is easier to distinguish between the sexes than at other times, for in addition to the brighter colors of the male, some species develop secondary sex characteristics, such as pearl organs, which are horny projections which appear particularly on the head and pectoral fin areas.

Sexual maturity is attained by various species at various ages. Even within the same species there will be variations from lake to lake and region to region, depending upon many factors. Chief among the factors affecting sexual maturity are food, light, temperature, age and size. When fish have adequate, proper food their health condition is good and growth and development is rapid. Therefore, they can attain sexual maturity a year or more before other fish of the same species in poorer conditions. Temperature also plays a part. Tropical fish develop rapidly and some fish may attain sexual maturity in 6 weeks after birth. Other fish living in cold waters may take as much as 20 years to attain maturity. Light conditions can also be an influence on maturity, especially in artificial hatchery conditions. Regulation of light can increase or decrease the rate of maturing. Generally, however, most species follow a pattern that is quite uniform. Some species take so many months or years to mature and in only exceptional conditions does the individual vary from this pattern. Thus we have fall spawners, winter spawners, etc. The knowledge of when sexual maturity occurs is important in several respects. For example, if a fish usually does not attain maturity until it reaches a length of 30 centimeters and fishermen are permitted to take the fish at lengths of 15 centimeters or less, a serious overfishing could threaten the very existence of the species. In selecting species for rearing in artificial conditions, it is important to know how long the fish would have to be held before they would spawn. Those species having a long period forreaching maturity would hardly be economical to raise. Similarly, those that reach maturity in a very short time also present the fish culturist with a big problem. This latter type is shown by some species of Tilapia and people must be accustomed to eating very small fish if this species is raised.

As fish reach maturity changes occur in the ovaries and testes. In Chapter I, we described the structure of the ovaries and testes. In the immature organs the unspecialized cells of the male are called spermatogonia, while the female cells are called oogonia. These unspecialized cells reproduce by mitosis or normal cell division. As the time of maturity and reproduction approaches, the spermatogonia and oogonia undergo a series of changes called spermatogenesis or oogenesis. These changes consist of two rapid cell divisions in which the number of chromosomes in the divided cells is reduced by half. These divisions differ from the normal mitosis in that the chromosomes which impart the hereditary characteristics to the progeny are reduced, while in normal mitosis the number of chromosomes remains the same in each divided cell as in the original.

In spermatogenesis these cell divisions produce four functional cells called spermatids, which by a transformation in shape become the spermatozoa. The spermatozoa (Fig. 96a) or sperm, as it is generally called, consists of a head piece and a whip-like tail. The chromosomes are located in the head and the tail is used for locomotion.

In oogenesis the same divisions take place, but only one functional cell is produced, in place of the four cells as in the male. After the final division the mature ova or egg does not change in shape as did the spermatozoa.

The mature egg (Fig. 96a) before it comes in contact with the water is enclosed in a heavy outer shell or chorion, and an inner shell, the vitelline membrane. A micropyle or opening through the chorion is present for the passage of the sperm. Within these shells are the components of the cell proper. The nucleus containing the chromosomes is located beneath the vitelline membrane and opposite the micropyle. The cytoplasm, or living material of the cell, minus the nucleus is collected in a band around the outside of the cell just beneath the vitelline membrane. Within this band is collected the non-living part of the cell or food material, the yolk and oil droplets.

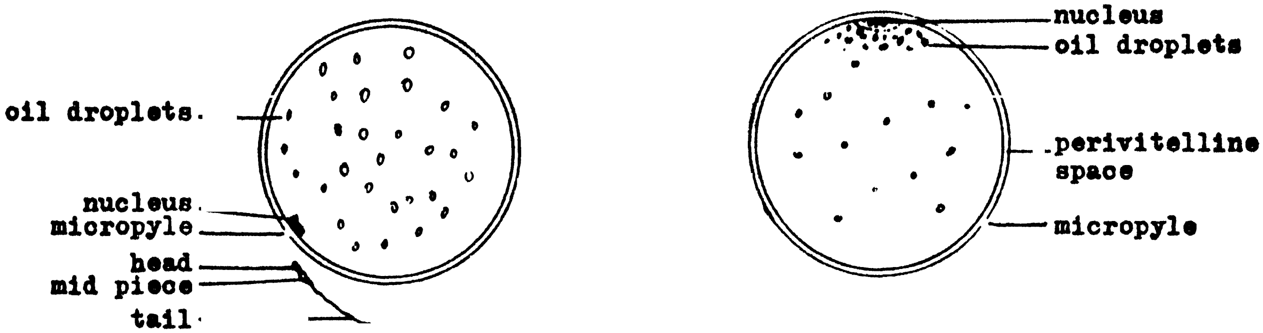
When spawning occurs the eggs and sperm are discharged into the water and immediately changes occur. The egg contracts slightly causing a colloidal substance to form between the chorion and the vitelline membranes. This colloidal substance takes up water until the egg is turgid. The perivitelline space (Fig. 96b) is formed in the process. As the perivitelline space is formed the egg within the vitelline membrane is free to rotate and the nucleus assumes a dorsal position on the surface of the egg. As a result of this movement the nucleus is no longer opposite the micropyle. During the water absorption process the cytoplasm also migrates from its position around the egg to a new position surrounding the nucleus at the top of the egg, forming a germinal disk. The process just described takes place whether the egg is fertilized or not.

Fertilization, the uniting of the egg and sperm, must take place before the water hardening process is very far advanced, because as soon as sufficient water is absorbed the nucleus starts to migrate, through rotation, away from the micropyle. One or more sperm may enter the micropyle, but only

Figure 96. Fish embryology

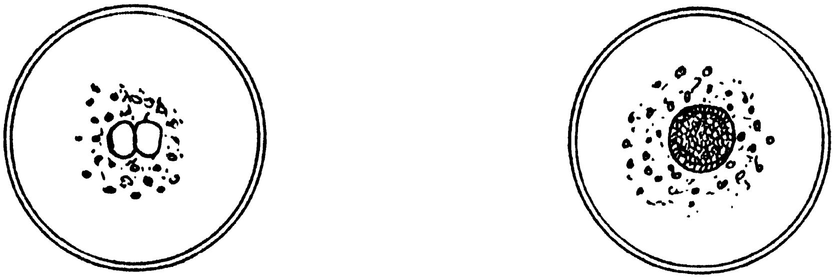
a. Unfertilized egg and sperm

b. Fertilized egg

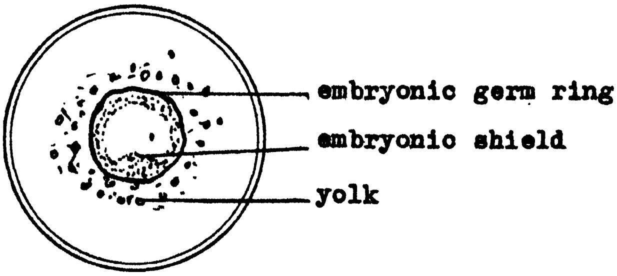


c. Two-celled stage

d. Early blastoderm



e. Germ ring



one fertilizes the nucleus. The head of the sperm containing its chromosomes unites with the nucleus and the tail piece falls away.

It is believed that the process of water hardening aids in fertilization by attracting sperm to the micropyle of the egg and into it as the water enters. Sperm are dormant in the testes, but upon entering the water they become very active, the tail piece whipping about driving the sperm forward. Sperm live up to five or more minutes after entering the water, but the first 30 seconds are the most active and the most effective fertilization occurs in that period.

Much of the detail of fish embryology remains to be described. However, the embryology of the salmon has been quite well worked out and will serve here as a basis for general fish embryology. Most species will follow this general pattern of the salmon, differing mainly in some of the parts and shape and time required for developing.

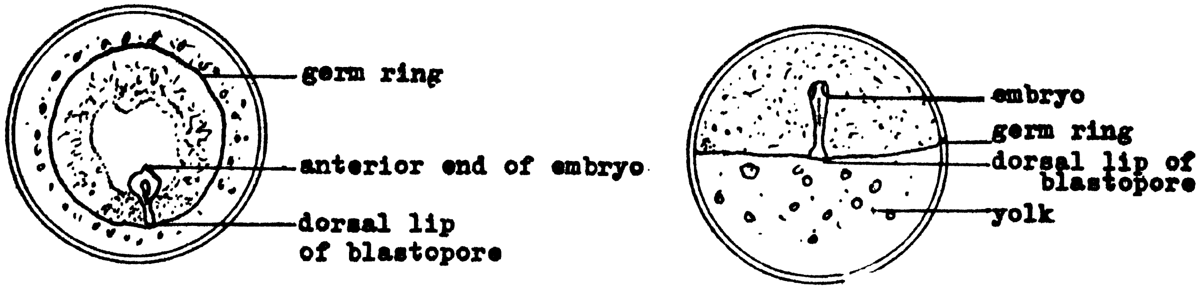
Shortly after fertilization the egg begins to divide. The division by which the single cell is converted into many cells is called cleavage. Cleavage (Fig. 96c) follows an orderly process, with one cell dividing into two, the two into four, and so on until the 128 cell stage is reached. Beyond the 128 cell stage, the cleavage is irregular and all cells do not divide simultaneously. During the early stages of cleavage the cells become smaller and more numerous with only a very small amount of total growth.

While cleavage is taking place, important changes occur internally. At the eight cell stage the central cells become separated from the yolk. This separation forms a hollow or cavity called the blastocoele and the hollow is filled with fluid. As the cells continue to divide, forming a multicelled layer, this cavity enlarges. At about the 128 cell stage, the embryo is called a blastula and is said to have reached the blastula stage of development. The germinal disk, which now contains numerous small cells, is called the blastoderm (Fig. 96d). During the blastula stage the size of the cells continues to be reduced and the division irregular. In the beginning of this blastula stage the blastoderm is high like the original germinal disk, but gradually it begins to flatten out and sink into the yolk. In the late stages of the blastula, the blastoderm begins to expand, but it still remains closely adhered to the yolk.

Figure 96. Fish embryology

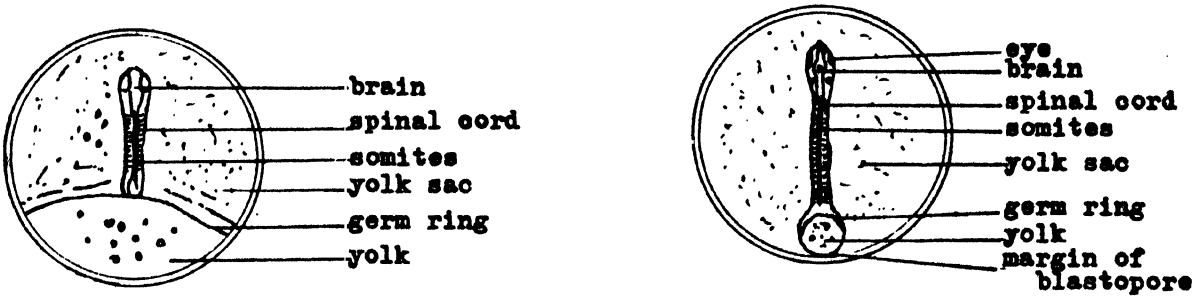
f. Embryonic shield

g. Five somite

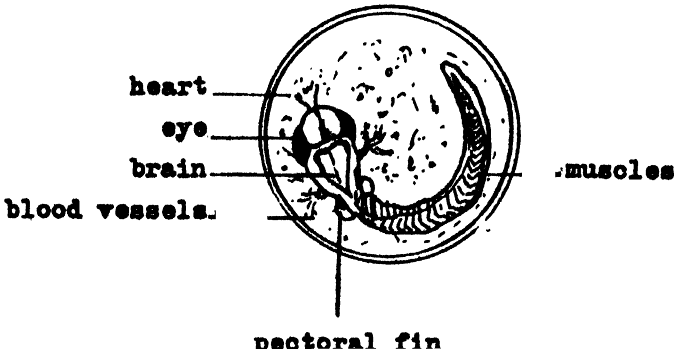


h. Seventeen somite

i. Thirty-five somite



j. Advanced embryo



As the blastoderm expands the cells at the edge become free from the yolk and begin to turn under or invaginate rather than to slide over the yolk. The invagination of the cells is the beginning of the gastrula stage of development. At the point of turning under or invagination the blastoderm is thickened and this thickened area is called the embryonic shield (Fig 96e). The invaginated tissue is called the primitive entoderm and from this is derived most of the internal organs of the fish.

As the blastoderm continues to enlarge and move down over the yolk a darkened ring is formed at its periphery which is known as the germ ring (Fig. 96f). The progress of the blastoderm over the yolk is uniform until the top half of the egg is covered. After the germ ring has passed the equator of the egg, the development of another structure in the blastoderm, the neural keel, is apparent. The neural keel is formed by a thickening of the cells in the center of the long axis of the embryonic shield, and will form the central nervous system and part of the eyes.

The germ ring as it passes the equator no longer moves uniformly over the yolk, but remains in a fixed position in relation to the embryonic shield. The germ ring closes in the shape of a continuously diminishing loop which eventually disappears. The area contained within the loop of the germ ring is known as the blastopore (Fig. 96g).

Only that part of the blastoderm which is adjacent to the embryonic shield will form the embryo. The function of the germ ring is the creation of the yolk sac which persists until the yolk material is completely absorbed by the growing fish.

The ectoderm is the only tissue present up to the gastrula stage. This ectoderm or outer layer of cells forms the skin and nervous system of the fish. The neural keel, which was mentioned earlier, is formed from the ectodermal layer through thickening of the cell layers and develops into the nervous system and part of the eyes.

When the embryo enters the gastrula stage, the cells of the blastoderm invaginate and this invagination forms the second layer of tissue called the endoderm. This endodermal layer develops under the embryonic shield into three separate parts. Directly down the center axis of the embryo the chorda (Fig. 96h) or primitive backbone is formed. Under this chorda the secondary endoderm develops into the digestive tract and its parts, including the air bladder and thyroid gland.

At the sides of the chorda the primitive endoderm becomes the mesoderm or third layer of tissue which gives rise to the muscles, skeleton, blood and all parts of the blood system, connective tissue, reproductive system and part of the skin.

Thus all parts of the body are derived from the three primary germ layers, the ectoderm, entoderm and mesoderm. The ectoderm gives rise to the central nervous system through the neural keel. The neural keel develops into the brain at the anterior end and the spinal cord posteriorly. As the embryo develops, after hatching, the brain is surrounded by the skull and the spinal cord by the spinal column, both the skull and column being derived from the mesoderm.

The principal sense organs are derived also from the ectoderm, either as outgrowths of the central nervous system, or as ingrowths from the epidermis. The eyes develop as outgrowths from the forepart of the brain. The eye lens are created by invagination of the epidermal layer. Both the ears and the nose are derived from the epidermal layer.

The digestive system is derived from the entoderm. The lining of the mouth is created by invagination of the epidermal layer of the ectoderm. The pharynx, including the gills, is derived from the entoderm. The liver, pancreas, stomach, intestine, air bladder and the majority of the endocrine glands are all entodermal in origin, but usually are combined with some mesodermal tissue, which forms the peritoneum, muscles and mesenteries of the digestive tract.

At about the time the blastopore closes (Fig. 96i), the muscles of the fish are starting to develop. The mesoderm divides into segments called somites, first in the mid-region of the body and later in the caudal region. The somites later develop into striated muscles of the axial skeleton (the myomere), and those of the appendicular and visceral systems. The embryo is capable of movement for a considerable period of time prior to hatching.

The kidneys are derived from the mesoderm as is the circulatory system. Cells called mesenchyme cells migrate out of the mesoderm onto the yolk and form blood islands. These blood islands form both the blood and blood vessels on the surface of the yolk. At the same time that the blood vessels are forming, the heart develops as an open tube in the region of the pharynx. The heart begins to pulsate before it is connected to any blood vessel and before blood is actually formed. The dorsal aorta located just beneath the notochord is the first blood vessel formed. Continuous with the dorsal aorta is a small vitelline vessel which leads from the junction of the tail with the yolk sac around the yolk to the anterior end of the embryo. This is the path of the first circulation of the blood. As the organs develop, the circulatory system develops simultaneously. As the kidney, spleen, thymus and lymph nodes are formed, they assume the blood making functions of the mesenchyme cells of the blood islands.

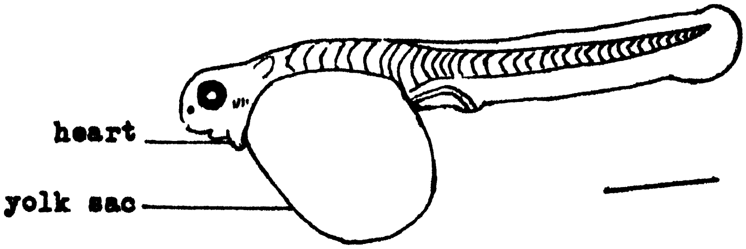
All the blood in the fish embryo passes through the yolk sac circulation before it goes to the heart. In the embryo the heart (Fig. 96j) is not contained in the body, but is located anterior to the head. As the yolk material is absorbed the vessels entering the heart come to be first ventral and then posterior to their original position. By the time the fish is ready to hatch, the heart has migrated from its position anterior to the head to a posterior position and ventral to the head.

The process of hatching is correlated with the development of glands in the mouth of the embryo which secrete an enzyme for the digestion of the chorion of the egg. The weakening of the egg shell by this enzyme plus the vigorous movement of the embryo causes the shell to rupture and the fry to hatch.

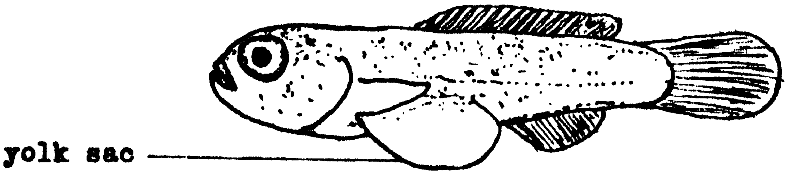
The period of development between hatching and when the fish begins to feed is called the fry stage. Changes continue to take place during the fry stage. In the egg the embryo was covered by an ectodermal layer. During the fry stage the mesoderm underlying the epidermal layer begins the development of scales. By the end of the fry stage, the rudimentary scales are formed in pockets in the dermis or mesodermal layer of the skin.

Figure 96. Fish embryology

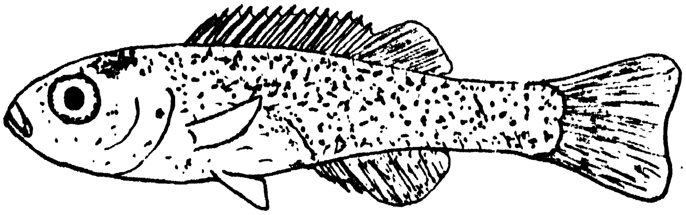
k. Newly hatched fry



l. Advanced fry



m. Actively feeding fry



During the later part of the egg stage and early part of the fry stage, the embryo has a very primitive kidney called the pronephros. During the fry stage the pronephros disappears and is replaced by the mesenephros. which is the functional kidney of the mature fish.

In the fry stage the brain is surrounded by the skull and the spinal chord is surrounded by the spinal column.

The migration of the heart continues and as the yolk is absorbed it approaches the normal position (Fig. 96 k, l) and when the fish begins active feeding the final withdrawal of the heart into the pericardial chamber or cavity is completed.

The primitive fins of the embryo consists of a fin fold (Fig.96 k) which extends as a continuous fin along the mid-dorsal surface of the body starting just posterior to the head and continuing to the tail. The fin fold is also present on the midventral surface from the yolk sac to the tail. It is from this primitive fold that the median fins are formed. Prior to hatching the regions of the dorsal, anal and caudal fins are enlarged, but the fin fold persists between the fins. The pectoral and pelvic fins appear first as fin buds or small projections. During the fry stage (Fig. 96 l) the median and paired fins are fully developed and the fin fold is absorbed. When the yolk sac is almost entirely absorbed the fry (Fig. 96 m) begins to feed and its free life begins.

Chapter V

The Growth of Fishes

A fish is different from most other vertebrates in that it continues to grow its entire life instead of reaching a full grown stage where growth stops as it does, for example, in man. There is a maximum size attained by each species. One does not find a specimen of Barbus canis growing to a length of 50 centimeters, although specimens of Barbus esocinus attain a length of 200 centimeters. Not all specimens of Barbus esocinus grow to 200 centimeters either, but it is a possible length to attain.

There are many factors which have an influence on growth. Some of these factors can be controlled by fishery biology and cultural practices, while others are not controllable. There are two major sets of these factors. The first is the internal group of factors acting within the fish itself. The second group includes the external or environmental factors.

The internal factors are the most difficult to do anything about, although it is possible to bring about changes in some of them. These internal factors include heredity, sex, sexual maturity, age, parasites, and disease. Heredity plays its role through the genes controlling growth. In hatcheries it is possible to select the best growing specimens for brood stock, and thus improve the growth rate of the species. In nature, however, heredity is a factor over which no control can be exercised.

Sex is a factor over which no control is possible. In some species the females grow to a larger size and weight than the males, while in other species the reverse is true, and still in other species there is no difference in the growth of the sexes.

The attainment of sexual maturity appears to have an influence on growth in that once sexual maturity is reached the rate of growth of the fish slows down. It appears that considerable amounts of the nourishment from the food taken into the body goes into the development of the sex products and therefore there is less food for growth of the body. Spawning itself may slow down growth, since in addition to the food required to develop the eggs and sperm, many species do not feed while they are nest building and guarding the eggs and fry. Then following this period the fish must rebuild the body tissues which were drawn upon during the period of fasting, thus prolonging the period of using food for other purposes than growth.

Age also influences growth. The most rapid period of growth is the first three to five years of life. In old fish, even though growth continues, it is a very small amount since it appears that increased size also makes it necessary for the fish to take more and more of the food for maintaining itself and in moving itself through the water, and therefore there is less extra nourishment for growth. For some as yet unexplained reason, it appears that the oldest fish are also the slower growing fish.

Disease and parasites influence growth in that they may be a deterrent to growth through infecting the digestive system or other vital organs, reducing their efficiency and thus providing less of the food essentials for proper growth. However, it has been found in some few instances that a slight infestation of certain kinds of parasites has apparently contributed to the increase in growth, since fish with a few parasites were of a larger size than fish of the same age with no parasites or with a great many parasites. A few parasites apparently stimulated the fish in some way to take on more food and thus had extra food for additional growth. It is preferable, of course, to have parasite-free fish, and every effort should be made to keep the fish parasite-free, since one cannot control the numbers of parasites to give the stimulation for extra growth, and usually you end up with fish that are very poor due to the infestations and the death loss as a result is very great. Fish that are free from parasites generally are the better growers in the long run.

As was mentioned earlier these internal factors are difficult to regulate or control, but in hatcheries and rearing ponds the fish culturist has some chance to control them, if he takes the proper time and precautions.

The external factors which affect the rate of growth of the fish include just about every environmental factor there is. Temperature and food are probably the most important factors. It is impossible to tell whether food or temperature is the more important. In temperate regions when the water temperature drops below 10°C., the fishes belonging to the warm-water group cease to feed or take on just enough food to maintain body processes. Thus even if there is an abundance of food the fish fails to grow. On the other hand, if the temperature of the water is the optimum temperature for growth and there is no food, the fish cannot grow either.

The cold-water species are adapted to feeding and growing in temperatures considerably below 10° C., but they too slow down in the lower temperatures and grow best at warmer temperatures. For example, the brook trout of North America is a cold water species which is generally considered to die in temperatures which go above 25° C. for any lengthy period of time, yet it is known to grow best in water temperatures between 20° and 21° C.

Temperature has its influence on metabolism. Once the temperature reaches 10° C. and the fish starts to grow, there is a doubling of the metabolic rate for each 10° rise in temperature through the normal range of temperature tolerance of the fish. When the optimum temperature is reached and the temperature continues to rise, there is a slowing down in feeding and thus in growth. Continued high temperature may stop the fish from growing just as effectively as cold temperatures.

It has been found from studies of the effect of temperature on growth that when fish develop in cold water they usually have more vertebrae and scales and muscle segments than fish of the same parents which develop in warm water.

The length of growing season, which depends upon temperature, affects the size of the fish for its age. In warmer regions a species may attain a length of 30 centimeters and a weight of one kilogram in two years, whereas in colder climate it will take three to four years or more for the fish to reach the same measurements.

Temperature is a factor which is difficult to control even in fish cultural stations, unless the station is so located that there are water sources of different temperatures that can be utilized. The creation of shade or the removal of shade around ponds is one thing that can be done to make minor changes in the water temperature. This can also be done in natural areas, especially on streams, where bank cover may either be planted to create shade and cool the water, or remove shade to increase the temperature of the water depending upon the effect desired.

Food as a factor in growth is equally important with temperature. In waters with abundant food the fish should grow at an above average rate provided all the other factors are normal. It is generally accepted that under average summer conditions a fish will eat an amount of food equal to 10 percent of its body weight each day. As was pointed out under temperature, higher or lower temperatures will affect the amount of food taken in and digested.

Scarcity of food will cause small fish to die off rapidly and cause larger fish who manage to get small amounts of food to maintain themselves, but grow very little in weight or length. Presence of large numbers of fish of the same species can create this condition by overpopulation. A very successful spawning may result in so many small fish which require the same type of food that the supply in the lake is inadequate to supply the needs of all the fish. A few of the weaker ones will soon die, but the majority will continue to find small amounts of food to maintain themselves, but too little food to grow very much. A few of the larger specimens will find adequate food and make normal growth. As this large number of fish continues to live, it puts a strain on the food production of the lake and may create a situation of a lake well stocked with fish, but of such a small size as to be of little value to anyone. This condition when found can be corrected by using several techniques which are available to the fishery biologists.

On the other hand, it is possible to have too few fish in a lake with the result that the few fish present grow exceptionally well, but there are too few fish to make the lake a commercially feasible producer. In this situation it might be possible to create adequate spawning grounds, thus increasing the number of fish, or to stock the lake with young fish provided from the hatcheries.

Turbidity may adversely affect the growth of fishes, especially those of the sight feeding group. High turbidity will make it difficult for the sight feeders to see the food and thus they would not obtain adequate amounts to produce good growth. Also turbidity may seriously decrease the food supply by cutting down the sunlight and thus reducing the productive areas of the lake or stream. Excessive silt brought in by flooding streams may also bury food beneath a thick layer of silt and thus decrease the supply.

The chemical condition of the water may influence the food supply in several ways. Certain necessary chemicals may be combined with other chemicals in such a way as to be unavailable to the plants for food, thus cutting down the total food supply in the lake. Certain chemicals might also be so abundant as to become toxic to the fish or even kill them. This is especially true of certain pollution compounds. Lack of other chemicals may also reduce the food supply and thus the growth rate of the fishes.

Lack of oxygen and increase of carbon dioxide, hydrogen sulfide, or methane gas in the lower depths of the lake may have an adverse effect on the growth through forcing the crowding of the fishes into the upper limits of the lake and thus putting a strain on the food supply. Depth, too, has an influence on growth rate through several directions. One is that deep lakes tend to be poorer in productivity than shallow lakes because there is such a small zone of productivity to supply food. Thus on a hectare basis the production of fish is much less and the growth may also be much less than in shallow lakes. Also, the deep lakes tend to tie up chemicals in the non-productive deep waters while the surface waters may be lacking in these same elements. Deep lakes tend to have their lower reaches become oxygenless in both summer and winter periods and thus provide non-habitable waters.

On the other hand, extremely shallow waters may become so crowded with vegetation that there is no room for the fish, and may have adverse chemical condition or physical conditions occur which cut down on the growth rate of the fish.

Acidity and alkalinity have their effect on growth rates, too. Extreme conditions of acidity and alkalinity cause death of fishes and in milder areas may slow down the growth through limitations on the food supply. Generally a pH slightly on the alkaline side provides the best conditions for growth of food and thus growth of fish.

Another factor of the environment which affects growth is space. This has been briefly mentioned under overpopulation above. Space is a definite factor, but the exact manner in which it has its influence is not known. A good example of how the space factor works can be shown by the common goldfish. If you put a small goldfish in a small bowl or jar and keep it in good condition, the fish will reach a certain size and beyond that it will not grow even though it has adequate food. It seems to know that if it grows beyond that size it will not be able to live in its present place. Yet if you take the same fish and put it in a larger aquarium or outdoor pool, it will resume growth again. The same holds true for hatchery ponds. If you put the proper number of fish in the pond they will grow well, but if you increase their number greatly the fish will cease to grow even if more than enough food is put into the pond. Beyond a certain point it is impossible to crowd fish and get them to grow.

In expressing the growth rates of fishes, two main determinations are made. One is the coefficient of condition, the other is the length-weight relationship. The coefficient of condition is an expression of relative fatness or plumpness or robustness and is based upon the well-known cube law in which the weight of an object increases as the cube of its length. The formula for determining the coefficient of condition is: $W = KL^3$, where W = the weight of the fish in grams, L = the standard length of the fish in millimeters, and K is a constant. The method for determining the coefficient of condition is explained in detail in the chapter on Field and Laboratory Methods. A coefficient of condition of 1 or less indicates a long thin or slender fish, while a coefficient of 3 or 4 indicates a short fat fish. However, since most fish do not follow the cube law in their increase in length and weight, it is not possible to determine the weight of the fish if its length is known or vice versa from this formula. Therefore the length-weight relationship is worked out and used for this purpose.

The length-weight relationship is derived by using the formula of the general parabola -- $W = cL^n$, where W is the weight of the fish in grams, L is the standard length of the fish in millimeters, and c and n are constants. The methods employed in determining the constants and in arranging the data for the compilation of the length-weight relationship are discussed in detail in the chapter on Field and Laboratory methods.

Once the length-weight relationship has been established for a species, it is possible to make comparisons with new samples and to calculate the length or weight of a fish if only one of the measurements is available. If the new sample deviates widely from the established pattern, it is possible to tell considerable about the waters as a suitable environment. If the fish is heavier than the average for its length, it indicates above average conditions, if lighter then below average conditions exist and the biologist has a clue to the needs of the lake for improvement. A similar idea is obtainable from the coefficient of condition, in that the coefficient will be greater or less than the average, indicating the condition of the lake. However, some caution must be used in interpreting the results, since at times the fish may normally vary from the average. For example, just prior to spawning when the female is full of eggs, the condition factor is quite likely to be higher than normal, and again immediately following spawning the condition factor will be lower. Therefore, a knowledge of the time of year when the fish was taken and when the particular species' spawning season is are important items in evaluating the condition factor or length-weight relationship.

The study of growth rates of fishes thus can give the biologist the data needed for determining whether the lake is producing fish that are average, above or below average in weight, and give him a clue as to what might be done to correct the situation. Generally, there are enough waters having poorer than average conditions so that the biologist will have little time to spend on the above average lakes, although some study should be made of these waters to help determine what factors are making the lake better and how these conditions can be introduced into the poorer lakes to increase their production.

Chapter VI

The Age of Fishes

After Leeuwenhoek, a Dutch scientist, first looked at fish scales under a microscope in 1684 and recorded that there appeared to be "rings" on the scales and that he believed each ring represented a year-mark, many workers have looked at and speculated about the marks on fish scales. It was not until 1898 that the real proof that certain marks on the scales were actually year-marks was developed. In that year a German biologist, Hoffbauer, reported on his work and established the basis for modern scale interpretation. He studied carp in a pond and followed their growth over a period of years, removing from time to time scale samples which enabled him to follow the scale pattern and development. He discovered the presence of year-marks or annuli, and since that time workers in the temperate and cold regions have been able to use the fish scales in the interpreting of the age of the fish samples collected from various bodies of water. Methods have been developed for the calculations of the length of the fish at each year of life from scale measurements and relative rates of growth have been established for many species.

The scale method is based upon three major propositions. The first is that the number of scales on the fish remain constant and retain their identity throughout the life of the fish. Secondly, the annual growth of the scale maintains a constant ratio with the growth in length of the fish throughout its entire life, and thirdly that one and only one annulus forms each year on the scale.

Freshwater fishes have three types of scales, - the cycloid, ctenoid, and ganoid, as described in Chapter I. Of these types only the first two are suitable for age determinations. To describe the scale method we will use a ctenoid scale as typical of the process. You will notice on the scale (Figure 4c) that in the center of the scale there is a small, clear area. This is the focus of the scale and it represents the original scale bud or platelet of the newly hatched fish. Around this center are numerous ridges or circuli, which represent the successive stages in scale growth, though they seldom correspond exactly with the scale margin. On the anterior, concealed field are radiating grooves or radii. On the exposed, posterior field are the numerous tooth-like projections, the ctenii, from which the type of scale derives its name.

As the scale grows, each circulus is laid down first along the anterior margin and then it grows gradually around the scale. A close examination of the scale will reveal several incomplete circuli along the dorsal and ventral borders of the scale.

During the winter, growth is retarded or ceases entirely and the circuli do not grow to completion. With the warming of the waters in the spring to growing temperatures, growth is greatly accelerated and a new circulus is laid down on the anterior margin and rapidly grows around the scale. The incomplete circuli of the previous growing season do not grow to completion, remaining as they were during the winter stoppage of growth. The newly formed circulus therefore cuts across these incomplete circuli and this "cutting across" is one of the most conspicuous and trustworthy characteristics of the annulus or year-mark. It is by locating and counting these annuli that the age of the fish is determined.

In cycloid scales (Fig 4d) there is often much less cutting across of the circuli and more frequently a crowding of the circuli of the late fall and winter. Generally the cycloid scales are more common on the cold water species and these coldwater species tend to grow in colder water than the warm water species. Thus they may slowly add circuli all winter, but growth is slight and the circuli become very close together. This, under the microscope, gives the appearance of a darker band and this band is frequently spoken of as the winter band or winter mark. The outer edge of this band is taken as the edge of the annulus, because with the rising spring temperatures the circuli become wider spaced, again indicating the beginning of another period of rapid summer growth.

Not all scales can be used for age determinations. Some scales are lost accidentally, and others grow to replace them. These replacement scales are called regenerated scales and are easily detected because they have a large opaque center, approximately the size of the scale at the time it was lost. No circuli are present in the regenerated area and therefore the scale is useless for age determinations. Other scales may have peculiar marks so that they cannot be used for age determinations either. From one to ten percent of most scale collections are discarded by experienced workers. Experience will help the worker distinguish between spawning checks, starvation marks, and other marks which develop on the scales at times and confuse the beginner.

In any detailed study of the age and growth of fishes it is necessary to determine the time of year at which the annulus forms in order to be able to more accurately assess the true age of the fish caught in the early spring and summer. The knowledge of when the fish begins to grow will help the worker decide whether the band of growth on the edge of the scale outside the last annulus is new growth or the entire last years growth. Without such knowledge the age of the fish may be off a whole year and give an improper evaluation of the condition of the lake.

Fish, like race-horses, have a birthday the first of January. A year is added to the age of the fish taken between January 1 and the time of annulus formation. This is done to permit comparisons to be made on a calendar year basis. Samples may be collected from a lake during the winter and other samples are taken in summer. These later samples will have one more annulus than the winter collected scales. For example, a group of fish taken in the spring just prior to annulus formation may have an average length of 150 millimeters and have two annuli on their scales plus a margin of growth. Another collection is made soon after annulus formation and this sample will have three visible year marks now and a small margin of new growth. Suppose this second sample also has an average length of 150 millimeters. It would appear that there were two age-groups in the lake having the same size-range of fishes. In order to avoid this discrepancy one year is added to the fish taken prior to the time of annulus formation, and this keeps comparisons of size and age on an even basis.

Once age determinations have been made on a number of fish of a species, a general growth curve may be compiled by taking the average length of the fishes in each age-group and plotting the data on a graph. This compilation gives the average or expected size for each age under average conditions. Comparisons can then be made with new collections to determine how well the fish are growing for their age.

In order to increase the value of the data by increasing the numbers upon which the data are based, growth calculations can be made from scale measurements. The measurements are usually made on enlarged scale images through use of a specially constructed projection apparatus.

It has been stated that the number of scales on a fish remains constant throughout its life and that the scales grow in the same proportion as the fish grows. Thus there is a definite ratio between the fish length and the scale length. This ratio is determined by measuring the size of specially selected scales, called key scales, from a group of fishes. The key scales are taken by counting to a certain row of scales on the side of the fish and taking a certain number of scales from that row. Scales from the same position then have been taken from each fish and can be directly compared.

By means of mathematical procedure, which is outlined in the chapter on Field and Laboratory Methods, the bodyscale relationship is determined. This relationship is determined to find out whether a direct proportion method for size calculation can be used, or whether a correction factor must be added to the formula.

By measurement we know the length of the fish at the time of capture, the length of the scale is measured and the length of the scale to each annulus is also measured. If the scale is directly proportional to the length, we can determine the size of the fish at any past year of life by the following formula:

$$L_n = S_n \frac{L_t}{S_t},$$

where L_n = the length of the fish at the end of the n th year of life

S_n = the scale radius within the n th annulus

L_t = the length of the fish at the time of capture

S_t = the total length of the scale.

If the body-scale relationship is not a direct proportion, then the formula would be:

$$L_n = c + S_n \frac{L_t - c}{S_t},$$

where c = a constant, and the other symbols are as described above. The c or correction factor varies with each species and must be calculated for each if the calculated lengths are to be used.

Since some species of fish do not have scales, or have scales which are not satisfactory for scale reading, other methods have been devised to determine the age of these fish.

The length-frequency method is based upon the assumption that the lengths of fish of one age tend to form a normal distribution around a mean length. Ages are determined by locating the peaks on the graph following the plotting of the data. The length-frequency method is usable mainly for species which have a short spawning period and fairly short life span. For other species which have prolonged spawning seasons and a long life span there will be an overlap in sizes in the early years and in later years there tends to be an overlap in all species in size, thus making the length-frequency method unreliable for accurate determinations of age.

In fish that do not have scales or scales that cannot be read, the use of otoliths or ear bones, cross sections of vertebrae, other bones such as the opercles, and the spines and rays of fins have been used with success in some species.

The otolith used is the one found in the sacculus of the inner ear. As the fish grows, lime is deposited around the otolith and when the fish is growing rapidly the deposition is less dense than when the fish is growing slowly. Thus by locating the dense compact bands on the otolith the age of the fish is determined. Sometimes the otolith is ground and polished to make it easier to determine the bands, while other times the stone is cut in half by use of a very fine jeweler's saw.

Spines and rays are also used, especially the pectoral fin spine. A cross section of the spine is made at the very base of the spine and this is mounted on a glass slide and studied under the microscope. Again growth is represented by bands around the spine or ray, and by locating these bands the age of the fish is determined.

Where possible the use of the scales is preferred, but if the fish does not have usable scales, these other methods do aid the biologist in age determinations.

Another method of age determination is from fish of known age. Several methods have been devised for marking fish so that they may be recognized again at a later date. One method is to keep one group of fish in a pond, and follow them for several years as did Hoffbauer when he established the scale method. This may get complicated if the fish are early spawners and several groups develop. However, if they take several years to reach maturity or if the large fish are separated from the young fish shortly after spawning occurs each year, then this method is of value. It generally cannot be used with wild stocks of fish.

A more satisfactory method is the use of numbered tags which are attached in various manners to the fish. A sample of scales is taken at the time of marking and subsequent samples from later years will help confirm the validity of the year mark and give exact information on the amount of growth the particular fish made. One disadvantage of this method is that sometimes the tag interferes with normal growth and abnormal patterns of growth are represented on the scales. However, it does help in establishing the validity of the year mark.

The clipping of fins is another method, but this does not permit the identification of individuals for later comparisons. Only averages can be determined by this method.

The practical value of age and growth studies may be illustrated by the following applications of the work. A knowledge of age at sexual maturity is needed to properly regulate certain commercial fisheries and to conduct certain fish cultural operations. For example, if a particular species does not attain sexual maturity until it is a minimum of three years of age and 300 millimeters in length, and fishing is permitted with no set size limit on the species, it might result in such a reduction in population in a particular body of water as to make fishing for it unprofitable, or even the species might be eliminated. The holding of fish in the hatchery for brood stock was mentioned earlier.

The comparisons of rates of growth between bodies of water or under different environmental conditions will identify good and bad conditions and point the way to future corrective work.

The success of attempts to improve the environment can be determined by the comparison of growth before and after the work is done. Improvement in growth rate will reflect good results.

The selection of waters to perform improvement work upon can be made from growth studies. Lakes with fish below average in length and weight indicate poor living conditions and the need for corrective work. Tests can then be made to determine what factor or factors are limiting the growth and steps can be taken to correct these faults. Thus age and growth studies are valuable tools to the fisheries biologist and culturist.

Chapter VII

Food and Feeding

It is difficult to set up a rigid classification of food habits of fishes since there are so many gradations and overlaps due to the circumstances prevailing at the time and place where the fish is located. But in general fishes may be grouped into three main categories according to the principal or major type of food eaten. These three groups are: 1. Herbivorous -- feeding mainly upon plant material; 2. Carnivorous -- feeding principally upon animal matter; and 3. Omnivorous -- feeding about equally on both plant and animal food. It must be remembered that there will be occasions when, for example, a carnivorous species will be forced to feed upon plant material because of a scarcity in its preferred food items. It is necessary, therefore, in classifying a species as to its food preference that a large number of samples be taken from many different localities for examination before a definite statement can be made. When a sample of fish is taken from a particular body of water, and the general food habit of the species is known, and a different content is found in its stomach, it is a good indication that the habitat is not well suited to that species.

Food is a major controlling factor in the number of fishes a body of water can produce, and in the distribution of fish. The production of food may be quite simple or may be very complex, involving many steps or stages. We generally speak of these processes as food cycles or food chains. For example, the food cycle or chain for an herbivorous fish is simple. The green plants obtain their necessary food elements either from the water or through the soil. The chemicals needed for this plant production, of course, come from the surrounding lands with the water entering the lake or stream or from decomposition of dead plant and animal material in the water through the action of bacteria. Thus the chain is short -- chemicals to plants to fish. In other species, as in the carnivores, the process may be very complex and go through many different stages. For example, a large adult carnivore depends upon food items of rather large size -- other fish, crayfish, large aquatic insects. These animals in turn are dependent upon smaller items and these on smaller, etc. Some of the smaller fish may be herbivores where the cycle for their food is short as described above. Some others, however, may be carnivorous or omnivorous and have complex cycles also. These fish require other animal food such as fry, small insects, plankton, etc. These smaller forms depend upon plankton or detritus or the basic chemicals. Basically all animals are dependent upon plants for their food supply and existence. Thus all food chains start with the basic chemicals and go through innumerable steps to reach their final destination.

To be productive then a lake must have the needed chemicals to supply the needs of the plants in the water. The plants require light to be able to manufacture food, and thus if a lake is too turbid a shortage of food may occur. Lakes or streams found in poor farming areas are very likely to be poor producers too, unless streams entering the lake pass through areas of richer fertility. The shape of the lake, its depth and other physical features play an important part in the production of food as well as fish. Generally a fairly shallow lake with a very irregular shoreline produces a great deal more than a round lake that is very deep. The shallow lake affords closer contact between the waters and the plants and bottom soils, thus giving easier access to the minerals. The shallow lake is also warmer and being subjected to winds the water moves easily and mixes, bringing oxygen to the bottom organisms which in turn speeds up decomposition of detritus. In deep lakes generally most of the year there is a lack of oxygen at the lower depths and decomposition depends entirely upon the anaerobic bacteria. Also with only a brief mixing in the spring and fall, most of the chemicals produced by decomposition remain unavailable to the plants in the upper productive zones.

Not only do the physical and chemical and biological characteristics of the water have an influence on food production, but they also play a major role in the food habits of the fish as well. The food habits of a species will vary with the size of the fish. A newly hatched fry will feed at first upon the stored up yolk material within its yolk sac. As soon as this material is used up, the fry must search for food. Generally the first food is small plankton organisms. If the correct sized plankters are present, the young fry may thrive, but if food of proper size is not available, the fry soon die. The importance of proper sized food may be illustrated by an experiment which was carried out in a laboratory. As newly hatched fry reached the stage of searching for food, small plankton crustaceans were added to the aquarium. However, many of these animals were too large for the fry to capture and swallow. Some fry tried to capture these larger organisms and found them too big, and they tried again and by chance once more got an animal that was too big to swallow. After several such attempts the fry gave up any further attempt to feed and died of starvation. Other fry were more fortunate and on the first or second attempt captured an organism they could swallow. These fry upon finding one too big did not quit trying, but kept searching until they found a proper sized organism and thus continued to grow.

As the fry obtains food and grows it may shift to bigger and bigger items of food, although this is not necessarily true of all species. Some remain plankton feeders all their lives, while some carnivores begin immediately to eat fish by eating their brothers. But generally there is a shift from small to larger items of food as the fish grows to adult size.

There are a number of factors which help in determining what a fish will eat. Size of food has just been mentioned. It can play an important part not only in young fish, but in adults as well. Availability also has a place. Some fish may prefer items such as crayfish or larvae of larger aquatic insects, but because of the poor productivity of the water these items are not present and therefore they must resort to other items for existence. Also some types of lake bottoms provide excellent hiding places for food organisms and the fish just cannot get at them. Taste also may have a place. It has been shown that some aquatic insect larvae have a taste that fish do not like and other larvae have mimicked them so that when the bad group is fed to the fish first, they taste but reject them, and when the imitator is put in right after the bad tasting group, they are not touched. It would also seem that texture has some effect in some species. Fish will take certain items into their mouths and reject them, while other species will pick up the rejected item and eat it. Color, too, has a bearing and is a very greatly contested factor. Some workers believe very strongly that color has a big place in feeding, so much so that in some hatcheries they add food coloring to the prepared food they feed the fish. Other workers believe that color does not have any real place in feeding. It is an item that needs some careful investigation.

Temperature has its effect. As was mentioned in the chapter on the freshwater environment, within normal temperature ranges, the fish double their metabolic rate and thus their food intake for each 10° C. rise in temperature. Experiments with warm-water fish show that once the temperature of the water rises above 10° C., the food intake increases and the fish begins to grow. Below 10° C. the fish takes on food, but only replacement nourishment is derived. Fish belonging to the cold water species will continue to grow to temperatures somewhat below 10° C., but they too reach a point of little or no growth.

Feeding habits play a role in determining what a fish may eat. Perhaps a distinction should be made now between food habits and feeding habits. Food habits refers to the kinds and amounts of food a fish eats. Feeding habits refers to the time, place and manner in which the food is obtained.

Fishes are adapted to their food in structure as well as in habit. As was shown under the chapter on Anatomy, fishes have a wide variety of shapes of mouths, teeth, and intestines. Mouths vary from tiny openings at the end of a long tube-like structure which enables the fish to eat a particular kind of animal in coral, to the meter wide, enormous toothed mouth of the killer shark. Some mouths are adapted to biting, others to sucking. Some have mouths pointed upwards on top of the head, as in Aphanius, or downward turned and sucker-like as in some Barbus, or Garra which has a regular sucking disk behind the mouth. Some fish like the Clarias and Tilapia have teeth in the mouth, while others like the Barbus have no teeth in the mouth but have throat or pharyngeal teeth which cut, tear or grind the food as it passes into the stomach. Also we find some fish which have short, stubby gill rakers and others which have long, narrow gill rakers. Those with the long gill rakers are usually plankton feeders and the rakers aid in filtering out the plankton as the water passes from the mouth through the gill slits.

The intestines of fish vary with food habits. Usually the carnivorous and omnivorous species have a distinct stomach, while the herbivorous fishes do not. The intestine itself is usually short in carnivorous species, medium length, that is with several loops, in omnivorous fishes, and very long, many looped in the herbivorous species. It takes a much longer time for digestion of plant than animal foods and thus the longer intestines.

Food is detected by sight, smell touch or taste. Most fish obtain their food by sight. They swim about in search of food and pick out the food they desire. Plankton feeders, for example, search for concentrations of plankton and proceed to feed upon it, yet completely ignore schools of small fish. Many fish will seize an object swimming past them without discrimination as to whether it is the right size or whether it is edible. These fish depend upon taste and feel, after capture, to tell them whether the item is to be swallowed or rejected.

Bottom feeders generally depend upon touch for finding food. Barbels attached about the mouth are used to locate food. Most night feeders depend upon smell and taste for finding food. Others may depend upon sound -- hearing their food swimming or crawling about. The air bladder and lateral line canal system aids these fishes.

The physical environment plays a major role in feeding of fishes. If a lake containing many sight feeding fishes becomes increasingly turbid, the sight feeders have difficulty in locating food. In such lakes the smell and taste and touch feeders have much greater success. Continued turbidity can in time change the fish population through gradually starving out the sight feeders.

Competition between species and between members of the same species for the same foods can also affect the size of the population as well as the size of the individual fish. When several species of similar food habits occupy the same waters, it is possible that the food supply may be so heavily utilized that there is insufficient supply for all to make good growth. Then a condition of overpopulation and stunting will occur. This same condition can develop within the same species as well. An exceptionally successful spawning season may be the start. Adequate plankton is available for the many fry and they survive. But when they need to shift to other foods there is an insufficient quantity. Then some of the more active and vigorous specimens will be able to catch adequate food and make normal growth. Others will find some food, but not enough to make good growth and they will be small for their age. Some, of course, will not find even sufficient food to exist. The quantities of food needed by the various species depends on the food habit, the food available, and the conversion rate. The temperature of the water and the general condition of the fish also play a part in the quantity of food used. It is generally accepted that the fish will use from 6 to 10 percent of its body weight in food each day in water of 20°C.

Insufficient quantities of food may cause malnutrition and the results of this are a lessening of vigor of the fish, making it more susceptible to disease and parasite. It also will reduce the reproductive capacity.

Food shortage is probably the most common and serious factor limiting fish production in natural waters. It is one of the major tasks of fish management to determine the exact food conditions and to make the necessary adjustments of the environment to correct the weaknesses in the food chain, if possible. Many tests and collections of data are concerned with the determining of the food supply. Food habits studies by stomach analysis show what the fish eats. Collections of plants, bottom organisms, and plankton give indications of what foods are available and estimates of their quantities. Chemical analysis shows what basic fertility is present and available to the plants and animals. Physical data will indicate whether the lake or river basin and the waters are suitable for good production. Analysis of all the data will show where the weak spots are and whether it is possible to apply any corrective measures. One of the best tests of lake productivity, of course, is the fish themselves. If samples indicate they have attained an average or above length and weight for their age, are in good healthy condition, and in good numbers, it can be assumed that the lake is suitable for that species. If, however, the fish are in poor condition, very small or very light for their age, and either in small or excessively large numbers, it can be assumed that the waters are not suitable under the present conditions and that corrective measures must be applied. The measures which can be applied are discussed later in the chapter on Lake and Stream Improvement.

Chapter VIII

Competition and Predation

While it is the custom to speak of competition and predation as separate items, the two problems are very closely related and many of the manifestations of each might be put in one or the other category depending largely upon the circumstances under which it occurs.

Predation generally has the meaning which signifies the destruction by consuming, and predators are usually referred to as enemies. Competition generally designates a contest between two or more organisms for the same thing.

Two major types of competition are to be found. There is interspecific competition, which is competition between two or more species and intraspecific competition which is competition between two or more members of the same species.

Interspecific competition involves a very wide variety of animals and plants. There is competition for food, which is probably the most important of the relationships. Under the chapter on Food and Feeding this relationship was briefly mentioned. If several species of fish, having the same food habits, inhabit a certain body of water, the pressure on the food supply may be so great that the food becomes so limited as to be insufficient for all the fishes feeding upon it. Thus there will be a change in the growth rates, with only the strongest fish or species managing to grow well. The others must either subsist on a below normal diet or shift to a secondary food supply.

There is also competition for nesting or spawning locations. This might lead to curtailment or reduction in numbers of a desirable species by a more aggressive, but less desirable one. The stronger fish can keep the weaker species off of its favorable spawning grounds, and thus cause the weaker species to seek less desirable grounds where chances for good survival are much less. Sometimes hybrids may be produced in competing for spawning grounds. Two closely related species having the same spawning requirements might nest in the same area, and produce accidental hybrids by having sperm of one species in the water when eggs of another are in the process of being laid, or as frequently happens the males of one species mate with the females of another, producing the hybrid.

Nesting sites may also be destroyed by successive spawners. The one pair of fish prepare their nest and deposit their eggs, and another pair comes along and destroys the nest while making its own nest. In areas of limited spawning grounds this can be a serious deterrent to adequate population.

Competition for space is another type. This was discussed under growth of fishes. The crowding of too many species or too many fish in the same area has an adverse effect on growth. There is also the competition between plants and fish for space. The vegetation may grow so thick in places in lakes that the fish are unable to utilize the area, and there is a competition not only for space but for chemicals and gases. In the daytime the plants can produce an excess of oxygen, sometimes to the point where it becomes harmful to the fish, and then at night the plants use so much oxygen that the supply is decreased to a point where fish may die from its lack.

Intraspecific competition includes all the items mentioned above and in addition there is competition for mates. Rivalry among the males for females includes the development of accessory sexual organs such as horns on the head and brilliant colors for attracting the females. There is among some species actual combat between males.

Predation, too, may be either inter- or intraspecific. Among the species that are carnivorous or omnivorous feeders predation may begin very early in life with the young fry attacking their brothers. Others begin feeding on other species of fish or on other animals. In turn the fish are fed upon by other animals. Frogs, birds, some mammals, crustaceans, insects, and other animals are known to feed upon fish. The number of predatory species in a lake or stream may control the population. Too many predators can be harmful to fish production. On the other hand, the lack of predatory species may be just as harmful since then the other fish populations may overproduce and create a situation of too many fish for the food supply. In natural waters one of the problems of the fishery biologist is to maintain a proper balance between predatory and non-predatory species.

One of the most serious competitor problems is the coarse fish problem. By coarse fish we mean fish which are not generally used by people for food. There may be various reasons why they are not used, but the fact that they are not creates the problem. Some of the coarse fish may not even be used by predators because they have big spines or other objectionable features to protect them. The problem of these fish is that they utilize great quantities of food which could otherwise be used by the fish which are of value. Generally, too, the coarse fish are very prolific spawners and are hardy fish which can tolerate conditions which many of the preferred fish cannot. Methods for controlling the numbers of these coarse fishes or finding means of utilizing them are matters on which fishery biologists are working. In some species some success has been achieved through the use of the fish as fish meal and fertilizer, or in oil production.

The introduction of species into areas where they are not native may also create a problem in competition and predation. Before a species is introduced into a new region, it should be thoroughly investigated. The species might be a useful predator under its natural condition, but when introduced into a new region it might take to preying upon the desired rather than the undesired species. Or it may become a strong competitor for spawning grounds or food of the native species and drive them out or severely reduce the population or cause a retardation in growth.

Care must be taken to ascertain whether the proposed introduction, if considered as a food fish, will be acceptable to the people. If possible in this matter, samples should be imported and tried before mass introductions are made.

Test introductions can also be made in waters which have no connection with major drainages, and where if the fish turns out to be undesirable it may be eliminated.

Another big problem in competition is man. Man has probably done and is doing more harm to the fishery than all other animals combined. Man utilizes the fish for food and in acquiring his supply uses large nets and various other devices. Many of the nets used are harmful to the fish population because of their small mesh size. They take fish of small length, before they have been able to spawn. They take and kill small fish which cannot be used for food and thus destroy future supplies. Since most fishermen follow traditions, it is very difficult to convince them that they are hurting the supply. Now as we need more and more fish for our food, it is very urgent that every effort be made to conserve the supply. Stringent laws must be passed to force the fishermen to use the proper sized nets.

The use of dynamite and poisons must also be stopped because they, too, destroy whole populations, leaving nothing for the future.

Man also competes with the fish for water. Water for domestic use and for irrigation or commercial factories takes from the fish his necessary medium. After use of this water by man, it is generally returned to the rivers and lakes, but it is so badly polluted then that it is no longer fit for fish use.

Huge dams built for power or irrigation and flood control, while undoubtedly necessary uses, can in many places be more wisely used and permit fish production, too. While some works of the past are detrimental to fisheries, there is no reason for those of the future to follow the same pattern. Proper planning to include fisheries will permit wise use of the water for everyone.

Chapter IX

Aquatic Plants

Aquatic plants, both micro- and macroscopic, are closely related to fish production. Since animals cannot organize food from inorganic substances, they are dependent upon plants which grow on these inorganic materials. The fish either feeds upon the plants themselves or upon other animals which feed upon the plants. Without plants there can be no animal life. While this nutritional connection between plants and animals is undoubtedly the most important influence of plants upon animals, there are other ways in which plants have an influence on the life of animals.

Both plants and animals require oxygen to maintain life. In running waters there is usually sufficient oxygen dissolved in the water to support animal life. However, in lakes and ponds conditions may arise which do not provide adequate supplies of oxygen. The plants manufacture oxygen and release it to the water where it contributes to the supply for fish and other animals. Plants also use up carbon dioxide and other chemicals which might, if not used by them, become so abundant as to be harmful to fish life.

The plants, especially some of the higher forms like the water lilies, potamogetons and arums, provide a surface upon which various kinds of organisms live, grow and reproduce themselves. Without certain kinds of vegetation some species of insects cannot develop. Protozoa and other lower forms of life also grow upon the stems and leaves of the plants providing food for fish and other animals.

Aquatic vegetation also provides a place of shelter for the fish and a protection from enemies. Weed beds provide a place for small fish to hide from the larger predators, as well as providing food. Weed beds also provide some protection against storms by cutting down the wave action and thus giving a quieter area for fish to live.

Another beneficial result of higher aquatic plants is the stabilization of the bottom soils. This reduces turbidity and provides a better habitat for the fish. Also by decreasing the shifting and stirring up of the bottom soils, the aquatic insects and other forms of life living in the bottom soils are better able to maintain themselves, thus providing more food for the fish. Shifting bottom soils cover up the organisms and destroy their homes. The roots of the plants and the stems and leaves reduce the wave action and water motion and prevent the shifting of the soil.

Weed beds serve as a breeding area. Many species of fish require aquatic plants in order to properly reproduce. Fish, like the yellow perch, entwine the gelatinous strings of eggs among the stems and leaves of the plants. Other species will stick their eggs to the underside of some of the leaves. Others with adhesive eggs drop their eggs in the vegetation and the eggs stick to the plants and develop. Should these eggs fall to the bottom soils they would become covered with silt and fail to develop.

The higher aquatic plants are not only beneficial in life, but after death they increase the nutritive elements in the soil and water through their decomposing. These elements are then used by the plant plankton and later generations of the higher plants.

Not all of the effects of aquatic plants are beneficial as far as the fishes are concerned. Some of the above described features may easily become very detrimental to fish life.

At times during periods of bright sunshine and calm weather a condition of supersaturation of oxygen may result. The plants manufacture so much more oxygen than is needed or can be distributed in the water that the area becomes supersaturated with oxygen. Fish swimming in this area absorb more oxygen than their systems can use and bubbles of oxygen form in the flood stream. Death has been known to result from this condition. One form of the disease is known as pop-eye and is caused by the accumulation of oxygen bubbles in the eye. The bubbles cause the eye to swell greatly and protrude from the sockets. In severe or prolonged instances, the eyes have been known to rupture causing blindness. Not all conditions of pop-eye are produced by supersaturation of oxygen, since other causes may also produce this effect as will be shown later.

At other times the plants may produce the reverse effect. Plants in abundance require large amounts of oxygen to maintain themselves during the hours of darkness when they cannot manufacture their food and oxygen. At times plants may use so much of the oxygen supply in the water as to reduce the quantity below the level which the fish require and many fish may die from lack of oxygen. This is particularly true in some types of hatchery ponds and rearing ponds where fish may be crowded. This is one reason for having night watchmen on hatchery grounds.

The decay of plants may reduce the oxygen supply, especially in the lower depths of the lake so that these regions become uninhabitable by the fish. In regions where ice covers the lake in the winter months this may become so serious that the oxygen supply becomes inadequate for the fish and there are numerous records where fish populations of an entire lake have died from lack of oxygen during the winter.

The decay of plant material may also produce gases of decomposition which can accumulate sufficiently to become harmful to fish life or their bottom dwelling food organisms.

Some algae may cause obnoxious odors in the water or give the water a bad taste. They may even produce a bad taste in the fish flesh. Also some species of algae, especially some of those in the blue-green group, can produce toxins in the water which will kill fish.

While providing shelter and protection for fish, weed beds may develop so thickly that they occupy so much space that fish cannot manage to swim in the area or find space for spawning. They grow so abundantly that they cover the bottom soils so heavily that food organisms cannot live there any longer. Thus the overabundance of plants can reduce the food supply and habitat of the fish. They can so reduce the productive area of the lake that the fish population is reduced. Weeds can even reduce the lake itself by completely filling in the small bays and arms of the lake. Eventually lakes will fill up with vegetation and become marshes. In shallow lakes with productive zones covering the entire lake bottom, this process may not take very long. An example of a rapidly filling in of a lake can be given in the lake at Homs. Since the dike was completed, about one-quarter of the southwestern area of the lake has filled in with vegetation, and at present plants are encroaching to about one-half of the lake.

Overabundant weed beds may also contribute to an overpopulation of fishes. The young fish of some species may be so well protected from predation that too many survive for the food supply available for them and all the features of overpopulation are shown by the fish.

Weed beds may also hinder the harvesting of the fishes commercially. Large patches of weeds along the shore prevent the use of seines and other nets, thus also contributing to overpopulation and the wasting of good food supply. Weeds may be so abundant, too, as to prevent fishermen from taking their boats through the beds to open water where they might fish.

There are a great many factors which affect the growth of plants. Some of these factors are length of growing season, altitude, nature of the bottom soil, water level, exposure to waves, turbidity, shade, fertility of the water, presence of harmful chemicals, abundance of algae, abundance of fish or plant-eating animals, excessive growth of plants and man's activities.

Length of growing season has a direct bearing in that the longer the growing season the more likely it is that there will be an abundance of plants. Altitude affects plant growth in that the water temperature is usually lower in the higher regions and also the fertility of the water is less in the higher mountain lakes, resulting in less plants.

The nature of the bottom plays a large role. If the bottom drops off very rapidly there is a limited zone around the lake that can support plants. Generally the plants do not develop much below 7 or 8 meters in depth in clear water lakes. Shallow lakes are generally weedy, unless they are very turbid. The bays and arms of lakes that are protected from the wind usually have more vegetation. Open wave-swept shorelines are usually devoid of vegetation because of the shifting bottom and action of the waves.

Many aquatic plants are rooted in the soil and must obtain much of their nourishment from the soil, the same as land plants. If the lake soil is poor in nutritive materials then the plant growth may be small.

Acidity and alkalinity of the soil may also influence plant growth. The type of soil -- sand, gravel, marl, etc. -- also has a direct influence on the plant life. Some bottom soils are too easily moved by the water movements to allow vegetation to get a start. Others are too hard.

Exposure to wave action decreases plant abundance. The pounding of waves will tear the plants loose. The shifting of the bottom soils by wave action may not permit vegetation to establish itself or will bury the new plants before they can become large enough to withstand the movement.

Wave action, of course, can produce turbidity which cuts down the amount of light and thus the amount of plant life. Turbidity from whatever cause is most harmful to plant growth.

Shade, especially on streams, cuts down production of plants. Large numbers of floating plants, such as water lilies, can reduce the growth of bottom plants by reducing the light penetration. These floating plants can also seriously reduce the plant plankton through the light reduction.

Aquatic plants require nutrient materials in order to grow. Among the materials needed are carbon dioxide, lime, nitrates, and phosphates. Lakes in which these elements are not plentiful do not have luxuriant weed beds. Also waters that are very soft have few plants as a rule. Waters from rich, fertile farm land draining into the lake or river aid greatly in producing the necessary fertilizer elements for plant growth. Waters from very poor farm regions or waste lands do not provide the material in adequate amounts for good growth.

At times waters entering a lake or stream may contain harmful chemicals which reduce or completely eliminate plants. Acid water from coal mines or other places will destroy plants. Pollutant materials from factories or other industrial plants can be most harmful. In some very hard water lakes the deposition of lime on the plants will seriously reduce the vegetative growth.

Some species of algae, especially some of the blue-green group, can become so abundant as to utilize most of the nutritive material, leaving little for the other species. Or some other algae may grow so abundantly as to smother out the higher plants through reducing the amount of light reaching them. Some filamentous algae can so cover the bottom that the seeds from the higher aquatic plants cannot reach the bottom soil to germinate.

Plant eating species of fish and other plant eating animals may be so abundant as to seriously reduce the aquatic vegetation. Some species, through their habits of stirring up the bottom in search for food, may aid in holding plant growth down through increased turbidity as well as by rooting up the small and large plants.

Excessive growth of the plants may tend to self destruction by creating such a thick mass of rotting parts as to smother out new growth in following seasons.

The activities of man also can destroy vegetation beds. In man's desire for clear water and beaches for swimming, he many times goes to great lengths to remove weed beds. In seining for fish he destroys much vegetation. The use of boats, especially motor boats, can contribute to the turbidity of the water, thus reducing the light penetration and thus the plants.

The fishery biologist must study each body of water thoroughly to determine the role that the aquatic plants are playing. In some bodies of water it may be necessary to encourage the development of weed beds. In other bodies of water it may be necessary to take measures for the curtailing and even elimination of some aquatic plants.

The fishery biologist can do a number of things to promote the growth of plants if this is deemed necessary. Fertilization of the water can contribute to the required nutrient materials to aid in plant growth. Seeds and plants may be introduced into lakes to promote growth of weed beds. The standard practices for reducing turbidity may be put into use and by reducing the turbidity promote plant growth. Elimination or reduction of the species of fish which destroy vegetation may be effective in promoting weed growth.

If excessive vegetation is a problem, then other measures may be tried. The mechanical reduction of the vegetation is one means. Many devices have been developed for this work. Fish which depend upon vegetation for food may be introduced or measures taken to promote their increase, if present.

Chemicals may be added which will destroy the plants, but which will not kill many of the fish. There are a great many such chemicals available now, and more are being developed and tried each year, because excessive vegetation is much more the problem than is the lack of vegetation in most natural waters. The chapters on Field and Laboratory Techniques, and on Lake and Stream Improvement contain additional information on the management techniques.

Chapter X

Pollution

Pollution is the discharge into water of any substance which may become harmful to the plants and animals in the water and unfit for human consumption. The materials so discharged into the water are called pollutants.

The effects of pollution on fish life may be either direct or indirect. Some of the direct effects are mechanical injury to the body, especially the gills. Abrasive compounds may cut and erode the delicate gill membrane. Some salts and acids will corrode these membranes or may be deposited on them, cutting off the respiratory surface from the oxygen supply. Other chemicals are directly toxic to the fish. The osmotic pressure may be changed by the presence of salts. Freshwater fish will die when the osmotic pressure rises above that of their blood.

Indirect effects include the covering of the spawning beds with silt and other material, the decreasing of oxygen through addition of oxidizable material, the increase of acidity or alkalinity beyond the tolerable limits, the destruction of food organisms or rendering them unfit for food, the stopping of migration, and the more rapid filling in of lakes and ponds.

Pollutants are generally divided into four major groups: 1. Sewage; 2. Industrial wastes; 3. Mining wastes; and 4. Silt from erosion. Of these four main groups, sewage is probably the most widespread, though usually not the most detrimental to aquatic life. Sewage, in moderate amounts, entering a lake or stream may actually produce conditions of enriched fertility and produce more plants and animals than non-sewage polluted waters. However, these polluted waters are a health menace to humans, create waters unfit for recreational uses such as swimming and bathing. Continued dumping of sewage soon removes the beneficial effects and the harmful effects come into evidence. Oxygen is decreased through the oxidation of the pollutant material and becomes so low in concentration even in running waters as to cause death of fish and other organisms.

The dumping of raw sewage into lakes and streams is something that should be eliminated. It is a practice that cannot be tolerated in modern times and with increasing populations it is not feasible to waste valuable water by pollution. It is necessary to establish sewage treatment plants where the sewage is properly treated. The effluent from a properly run sewage treatment plant is clean and clear, free from disease germs, odorless and largely free from oxygen-consuming substances. It retains the fertilizing elements which can aid in increasing the productivity of the waters. Only in a few places may this fertilizing effect be harmful. Some lakes which already have sufficient fertility may be harmed by the addition of more fertilizer. When these conditions are found, it may be possible to find other means of disposal of the effluent if the waters involved are deemed valuable fishing waters.

Industrial wastes are of a wide variety and are the by-product of the manufacture of some item of food, shelter, clothing or other material of value or necessity to man. They create a huge problem for the fishery biologist and sanitary engineer whose job it is to control the disposal of such harmful products. The effects of industrial waste are much the same as those of sewage, but in addition there are some industrial wastes that are directly toxic to the plants and animals. Again there may be some beneficial effects from some effluents through fertilizing effects. The problem of evaluating and controlling these substances calls for cooperation between the industry owners, the fishery biologist and the sanitary engineer.

Many of the industrial wastes are directly poisonous to the fishes. Others may make the water condition intolerable for the fish, causing them to leave the area although it does not kill them. They may stop migration of fishes upstream and keep the fish from their spawning grounds, thus reducing the fish population.

Many of the industrial wastes can be treated and rendered harmless to aquatic life, and where this is possible every effort must be made to enforce the laws governing treatment of wastes.

Mining wastes are also detrimental to fish life. Included in mining wastes are the brines and oil from oil wells. These materials are very harmful to the fish and their habitat as well. There are many method available for the control of oil wastes and these should be applied wherever oil wells are located.

Soil erosion is also considered as a pollutant. The eroding soil entering the water covers up the spawning grounds, food supplies, and fills in lakes and streams reducing the productive zones of the water. Soil from rich farm land in addition to the above may also reduce the oxygen supply by bringing in much oxidizable material. Again there are many methods which may be applied to prevent erosion, and some of these will be discussed in the chapter on Lake and Stream Improvement.

The determination of the exact effect of pollution is often very complex and difficult. The most obvious effect of pollution is a sudden large mortality of fish. By immediate sampling and testing of the water, the pollutant causing death may be found. However, the gradual effect or the accumulative effect are much more difficult to ascertain. Pollution experts have worked out in the laboratory through many tests the limits of toxicity of many pollutants. Yet even with these exact measurements, results in streams and lakes are often quite different. Other factors enter into the conditions and cannot be accounted for ahead of time.

Based upon laboratory and field tests and examinations, certain means and standards can be set which apply in most instances. Standard textbooks on Water Analysis, Sewage Disposal, and Sanitary Engineering give these methods and need not be given here.

In addition to the physical and chemical tests, there are also biological tests that can be made. One such test is the Test Organisms. In this method certain species of fish are placed under controlled conditions in the suspected polluted water. The reaction of the fish to this water is recorded. Goldfish are frequently used because they are a hardy species and survive under conditions which are generally more adverse than natural conditions. If the goldfish succumb to the conditions imposed it is quite certain that other less hardy species will die.

With the study of polluted waters there has been developed a system of index organisms. As pollution increases, the bottom fauna changes. Organisms that are very sensitive to the pollutants decrease or disappear.

Other organisms are more tolerant of the pollutant and remain or increase. By studying the bottom fauna one can then detect the degree of pollution by the organisms present.

In most instances there are three zones downstream from each harmful pollution effluent. First is the Zone of Immediate Pollution. This is where the pollution enters the stream or lake, and is often accompanied by odors or discoloration of the water.

Second is the Zone of Sepsis. This is the region of greatest effect of the pollutant. In this region there is the greatest loss of fish or other animal and plant life.

Third is the Zone of Recovery. This is characterized by the gradual return to normal stream or lake fauna and flora. The less tolerant forms are once again found, and there is the absence of the pollutant effects.

Pollution can and must be controlled. In areas where industrial development is being undertaken, steps must be taken to include in the construction adequate measures for the curtailment of pollution. Laws should be made and enforced on all cities, factories and mines, and oil-producing establishments to prevent the destruction of the fisheries as well as to preserve the waters for human use.

Chapter XI

The Diseases of Fish

The diseases of fish, including parasites, present an important problem to the fishery biologist. The infestation of food fishes with parasites and tumors and sores from diseases makes the fish unfit for sale. When the infestation of a disease or parasite reaches epidemic proportions whole populations of fish have been eliminated. In fish cultural stations, where fish are considerably more crowded than in natural waters, the problem of parasites and diseases is of even greater importance.

While considerable progress has been made in the identification of parasites and diseases and in the study of their life history, the problem of applying treatments is the major obstacle. In hatcheries and ponds it is possible to apply many techniques which have been developed, but in natural waters treatment is frequently impossible, even when the treatment is known and is effective.

Usually diseases of fishes may be placed in one of the following categories: 1. Disorders resulting from external physical and chemical agencies; 2. Dietary disorders and deficiencies; 3. Tumors and carcinomas; and 4. Infections by debilitating or disease producing organisms.

Under the first category are included the disorders arising from the adverse effects of the physical and chemical environment, many of which have already been described in earlier chapters. For instance, conditions of pollution will result in injury and death, although death does not always occur under conditions of pollution. Heavy deposition of silt from erosion may reduce the food supply and cause malnutrition in the fish. It does not grow normally and is less resistant then to other infections. Silt may also abrase the gill tissue and injure the fish through reduced oxygen supplies. Chemicals may be toxic to the fish, but in doses just below the lethal point may make the fish very sick and unable to grow or live naturally. If the pollution condition is corrected or of a brief duration, the fish survive but may take a long time to fully recover from the effects, thus affecting their size and weight.

Also included in this category are the traumatic injuries resulting from a number of causes. Collision with objects, bruising and abrasing the skin against sharp objects, unsuccessful attacks by predators may all result in injuries which leave scars or cripple the fish in some way. These injuries may result in death, but more frequently the fish recovers but is less able to grow normally and resistance to other infections is lessened.

Gas deficiencies and supersaturations may also cause disease problems. The accumulation of oxygen and nitrogen bubbles in the blood streams may cause death, or if accumulated in the eyes may cause blindness. Lack of oxygen has been discussed earlier but is a condition which seriously affects fishes, as does the accumulation of other gases such as carbon dioxide, methane, hydrogen sulfide.

Rapid changes in temperature may also have an effect on fishes, especially on developing eggs and young fry. These stages are very sensitive to the lowering of temperatures during their development. Death occurs very easily and many early spawners have their eggs destroyed by temperature change. The temperature of the water at the time of development has an effect on the number of muscle segments and vertebrae. Rapidly rising temperatures shorten the period of development and in this way the number of segments and vertebrae. Occasionally this sudden change can seriously affect the development of a whole group of eggs causing many deformities. These deformities, while not causing death, do reduce the ability of the fish to live normally and they may become more susceptible to predation and diseases.

Excess acidity and alkalinity also have their effect and may keep certain species from inhabiting certain waters. Should fish that are not accustomed to or adapted to these conditions be placed in these waters, death usually results.

Dietary deficiencies produce a number of changes in fishes. Dwarfing or stunting as a result of inadequate food is the most obvious. These stunted fish are short for their age, very thin and emaciated in appearance. Their lowered resistance also may bring about secondary infections. In hatcheries, where artificial foods are prepared, care must be taken to include vitamins, since lack of vitamins produces disease in fishes as in humans.

Too much fat of certain kinds in prepared diets will cause fatty degeneration of the liver with serious consequences to the fish population. Generally, however, in nature these vitamin or special dietary diseases do not occur. Lack of food is the major dietary disease in nature.

Fishes suffer from cancer and tumors the same as other animals. Again the causes of the cancer are unknown. Tumors or growths of and on other organs are quite common. Thyroid enlargement or goiter is common in fishes in regions where iodine is low in the water. Some modern cancer research is being conducted using fish as the experimental animal because the tropical fishes being used can produce many generations in a year, and thus the researcher can trace more rapidly the development of suspected lines of transmittal.

The fourth category, Infections, contains the largest number of fish diseases. This group includes the virus, bacterial, fungus, protozoan, worms, and all the other animal groups which produce disease or parasites on fishes. These diseases may either be internal or external. Only a few of the major or well-known diseases will be presented here, since space does not permit more. There are several books available on fish diseases and their treatments, and innumerable individual papers have been written on specific diseases and their treatment.

Probably the most dreaded bacterial disease in fishes is Furunculosis or Boil disease. Furunculosis is caused by Bacterium salmonicida and is very common, especially among trout and salmon. The bacteria get into the blood stream, and as they pass through the capillaries they tend to accumulate in small clumps and multiply rapidly and form lesions or boils in the flesh. These boils become full of pus and blood and may break open to form large ulcers.

Among the protozoan diseases, the "Ich" is the most common in fresh-water fishes. This disease is caused by the protozoa, Ichthyophthirius multifilis. The most characteristic symptom of this disease is the presence of small grayish-white patches or swellings on the body and fins. The fish tries to rub these patches off by scraping along the bottom or against objects in the water. In late stages of the disease the fish becomes sluggish and lies quietly on the bottom where it is easily captured.

A common internal protozoan is Ootomitis salmonis, which produces dysentery and can be a very serious disease in young fish.

Saprolegnia parasitica is a common water mold which attacks eggs and fish, especially those that have been injured and the skin broken. The fungus grows in white patches with the root-like filaments penetrating into the skin and eventually into the flesh. In severe cases death is produced. In certain temperature conditions saprolegnia will attack eggs in their nests and completely smother them.

Tapeworms are common in fishes and some may be transferred to man. One species which is found in man, dogs, fish, bears, racooons, and other animals is Diphyllobothrium latum. There is no danger of acquiring this parasite if the fish is properly cooked. Only by eating raw or poorly cooked fish can this tapeworm be acquired by man.

Various roundworms are found, also. Among the more widespread is the yellow grub, Clinostomum marginatum. The adult worm lives in the mouth of a water bird, usually a heron. Eggs are deposited in the water as the bird feeds. These eggs develop into a free-swimming larva, and this larva enters into a snail where it undergoes a period of development and produces a number of other forms known as cercariae. The cercariae leave the snail and swim in the water to find a fish. If they find a fish within a short time, they burrow into the fish and develop into an immature stage of the worm. If they do not find a fish they die. In the flesh after a brief period of growth the immature stage forms a cyst about itself and remains in this stage until the fish is eaten by a heron or other host bird. The grub is freed from its case by digestion of the flesh and case from around it in the heron's stomach. When free the grub crawls back up the throat of the bird and lodges in the mouth, where it grows to adult and the cycle begins again. These grubs are not harmful to humans, but they do detract from the appearance of the flesh and most people prefer not eat grubby fish.

Leeches or blood suckers very often attach themselves to fish and feed off of them. Seldom, however, do they destroy the fish.

Some varieties of clams have a parasitic stage in their development, when they must attach themselves to fish in order to be able to develop further. The larval forms are known as glochidia. Again, it is seldom that this glochidia destroys the fish. If death results, it is probably because of some other parasite or infection which is present and resistance was so low that one more parasite was too much for the fish to support, or the wounds made by the glochidia in their feeding permitted the entrance of another disease which caused the death of the host.

Among the Crustacea there are some parasitic forms. Two common copepod parasites are Argulus and Lernaea. These are commonly called fish lice. They attach themselves to the gills or flesh of the fish and feed upon the fish. Again only in severe cases is death produced, but heavy infestations can seriously hinder the fish in growth and in general health.

Even the fishes themselves have parasitic forms in their class. The lampreys contain several parasitic forms. The sea lamprey, Petromyzon marinus, has entered the freshwater Great Lakes of North America and through its parasitic habit have almost eliminated the lake trout from these waters. These lampreys attach themselves to the trout and bore holes into the flesh with their rasplike tongues and feed upon the flesh and blood of the host.

Death does not always result from the infestation of parasites and diseases. Many fish continue to live, malformed, with malnutrition, and full of parasites. However, these conditions spoil the fish for ultimate use as food. Fish that are heavily parasitized with external parasites, such as the grubs, lose all attraction as a table fish. People do not wish to buy and eat fish that are obviously full of worms, even though they know the worms are not harmful to themselves. Other parasites produce scars and sores in the flesh which make the flesh inedible. Disease also causes the fish to be in poor condition, they are thin and small, and few will buy fish that look in poor shape.

Disease also may affect the reproduction of a species, even though it does not affect their general condition. The bass tapeworm causes the fish to become sterile since it lives primarily in the testes and ovaries.

Thus it is of great harm to the general fish population by greatly reducing the reproduction of a desired species.

For these and many other reasons the biologist must take what measures he can to control and prevent diseases. The task is enormous in natural waters and often impossible under present knowledge. Yet no opportunity should be passed over. The fish culturist in the more controlled conditions of the hatchery has a much better chance to do something regarding diseases of fishes in his care. But also with the crowding of as many fish as possible into the area the problems of disease become even greater than in the natural waters, and great care and attention must be given to the proper handling of the fish or serious losses will occur.

Chapter XII

Lake and Stream Improvement

The purpose of lake and stream improvement is to provide the best environmental conditions for the propagation, growth and yield of the desired species of fish. Effective lake and stream improvement depends first on the recognition of the environmental requirements essential for abundant crops of fish and secondly on how these requirements can best be obtained.

In earlier chapters we have discussed most of the essential requirements for good fish habitats, such as temperature, depth, size, dissolved oxygen and carbon dioxide, hardness, acidity, alkalinity, adequate spawning conditions, suitable shelter, vegetation, food and protection from depletion. All the essential requirements for a good yield must be present.

It is the work of the fishery biologist to get the necessary information on the body of water under investigation to be able to determine the factor or factors which are limiting the fish production. The factor which is limiting production may either be absent or present in very small quantities, too small to allow good development, or it may be in too great an amount. In order to find out which situation applies, the biologist must make his studies of the habits of the fishes present, and a comparative study of the waters in his region.

It is therefore necessary to make observations as to when and where the fishes spawn, what sort of shelter they prefer, are they migratory or not, if migratory when do they migrate, what are the fishes enemies, are these enemies present in the lake in abundance, what food is preferred by the fish. This information may come from investigations by the biologist, from the reports of other biologists either written or verbal.

The comparison of local waters will provide information on what may be lacking in certain bodies of water. A body of water which is producing well is studied in detail, and another water which is not producing well is studied in the same manner. By checking item by item of the essential factors, it may be possible to determine which is limiting production.

The last chapter of this book contains the methods for conducting the lake and stream surveys, and provides samples of record forms for keeping the information obtained. Once the data is obtained and comparisons made with the known essential requirements of the fish, then steps can be taken to correct the deficiencies.

There are many books and articles written on the methods of lake and stream improvement. The methods used in other countries and areas can be used as a basis for any local work. The basic principles are the same, but adaptation to local conditions and materials is necessary, and is a most important role for the biologist. It is for the biologist to determine the elements that need correcting and to decide the best method for accomplishing this correction.

Some general principles, however, can be presented. A suitable water supply is, of course, a primary essential. The elimination of pollution is necessary to keep a good water supply. Control of erosion both in streams and in lakes may be necessary. If the banks of the stream or lake are continually being washed into the water, the silt and sand will cover up food supplies, fill in pools and generally destroy the fish habitat. There are many methods for eliminating erosion, and some of these extend considerable distances from the water itself. Farm land or cut-over timber land on the watershed may need to be stabilized before any work is done on the stream or lake itself. It is essential to get to the source of the trouble and correct it. Once the source is located and corrected, then work may proceed with good results in the waters. Devices can then be put in the stream to clean up the effects of the deposition of the silt. Deflectors, and dams, and digger logs and other corrective devices can be installed to keep the current moving faster so as to carry the silt away, to dig pools and provide shelter.

Once the water supply is corrected, other items may increase of their own accord. If the lake is too shallow, it might be possible to increase its depth by building a small dam at the outlet. A constant level of the water is an essential factor and a regulatory dam on the outlet may aid in this. If a lake is considered too deep, little can usually be done to correct this. Then the problem is to get the most production based on this limiting factor.

Adequate spawning conditions for the desired species may also be provided. In streams it may be that gravel beds are essential. In this case, if they are covered by silt, the construction of devices to speed up the water current may clear the gravel through the swifter waters carrying off the silt. If gravel is not present, it may be possible to haul some in from other sources and create a gravelled area in the stream or lake for spawning. If vegetation or pools are needed, other devices can be used to provide these. Sometimes it may be necessary to destroy spawning grounds if over-production of fry is found to be a limiting factor. Too many fish are as big a problem as too few fish.

If vegetation is needed and the factors limiting its production have been corrected, it is possible to speed up the development by seeding and transplantation. If vegetation is too abundant, methods are available to eliminate or greatly reduce it. In place of vegetation on barren, waveswept shore areas, it is possible to install brush piles. These piles of brush afford shelter, protection from enemies, and for some species a spawning ground. The brush piles also may substitute for vegetation for certain insects who need some surface off the bottom to develop. Algae and lower animals such as protozoa and worms may develop on the brush and offer food for fish or their food organisms.

The improvement in food supply may also be necessary. Sometimes the food supply is lacking or very scarce for certain desired species. Finding the limiting factor of the food supply and taking corrective measures is as important as the study of the desired species. The correcting of pollution and erosion may increase the food. Sometimes reducing vegetation and shelter to permit the fish to have access to avaialble food supplies is necessary. Other times it is necessary to protect the food supply to permit it to build up to a suitable quantity. The application of fertilizers may start a whole chain of events. If the waters are limited in the essential plant chemicals the application of these elements will increase the plant life, especially the plant plankton. In turn the animal plankton and other animals feeding on vegetation can increase due to increased food. With an increase in these forms, other animals feeding upon them may become more abundant or larger and so on until the food for the fish is increased.

Care must be taken of course not to over-develop the factors, which can be harmful. Too much fertiliser can produce too much vegetation which can reduce oxygen supplies and destroy most of the fish. Too much shelter can reduce the size of the fish by permitting too many fish to survive for the food supply.

It is also necessary to make continued studies and keep records of the catch. Fishermen may take too many fish in their netting operations and so reduce the population that undesired species may become dominant or leave too few fishes to adequately restock the waters. It is essential to keep accurate records of the catch.

Studies of the age and growth of the fishes aids very much in the determination of how well or poorly the water is producing. Good growth is reflected in the condition of the fish and on its scales. By studying the growth of the fishes and establishing norms, it is possible to keep a close check on changes taking place.

The improvement of lakes and streams is not a temporary or one-time work. It required constant attention and rechecking and adjustments in the management plans.

Chapter XIII

Commercial Fishing and Utilization

The principal aim of lake and stream improvement and management is to provide the largest population of desirable fishes that the body of water can produce. The ultimate end of this population is for human consumption. Fish provide a very excellent food and one rich in protein. Therefore, in any management plan the utilization must be considered.

In order to manage the fisheries properly, one must have a knowledge of the methods of commercial fishing and the gear used. There are a great many different types of fishing gear, and space does not permit describing all of them. Only a few which may have application in this region or are currently being used will be considered.

The spear is probably the oldest form of fishing gear. It most likely started as a pointed branch from a tree and gradually developed into one consisting of a metal tined head on a wooden shaft. While this method is still used, it is a very slow and tedious method, and generally a poor producer. It is most effectively used on migrating populations in shallow waters.

The hook and line method is also quite ancient in origin and is still in use. The method varies from a single hook on a line, to a line several miles long with thousands of hooks. The single line and hook is generally used for sport fishing, although in some areas commercial fishing may be done in this manner. Usually, however, one of several methods of long lines and many hooks is used commercially. A common method in inland waters is the trot line. This trot line may either be anchored or allowed to drift depending upon the species sought or the area fished. For bottom feeding species it is usually anchored. A float is put into the water and an anchor line of sufficient length to reach the bottom is let out and the anchor attached. The main line to which are attached the hooks is fastened to the anchor and let out of the boat. The hooks are fastened to the main line by short lengths of line and are usually baited. The hooks are so spaced that they will not tangle with one another. When the long line is completely set, it is attached to another anchor to which another float line is also attached. This float line is let out to a sufficient depth so that the anchor reaches the bottom and another float is attached. If very long lines are used, it is customary to add several anchors and floats in case the main line should break it is possible to recover most of the gear. This method can be used in rivers, lakes or the sea.

If a drift line is desired for species which live in mid-water or near the surface, anchors are not used and there are more floats used to suspend the hook line. The line then drifts in the current or as the wind moves the floats.

Another hook and line gear is the trolling line, which again may be a single line and hook or a number of hooks on the line, or several sets of hooks being towed behind a slow moving boat. Various types of hooks may be used. Some will be simple iron hooks to which bait is attached, others will have metal spoons or spinners, feathered jigs, plugs, etc. The type of hook and lure depends on the species sought, the season, the locality, or the preference of the fisherman.

Another type of fishing gear is the maze or barricade which consists of leading the fish into an enclosure from which escape is difficult. This type of gear includes fish pots, fyke nets, pound nets, weirs and racks.

The pot is a small portable trap which may be made of wood, wire, or fiber netting. It has a small entrance through which the fish enters. The shape of the pot varies with the locality and species taken. They may be cylinders, rectangles, half rounds, or ovals. The pots are usually most effective in capturing slow-moving fishes that move about on or just off the river or lake bottom. Catfish, eels and carp are frequently taken by these pots.

The fyke net is a shallow water gear and is used widely in rivers. It consists of a long net bag mounted on several hoops. There are one or more net funnels suspended from the hoops which prevent the fish from readily escaping once they have entered the narrow funnel opening. Sometimes short, vertical wings are attached to the first hoop which aid in guiding the fish into the first funnel. The net may either be set with anchors or with stakes. The fyke nets may also be used in lakes, especially in the places where fishes are known to move about.

The pound net or trap is very efficient for migratory species which follow shorelines. It consists of a very long lead or fence which directs the fish into a V-shaped construction called the heart, where the fish continue to follow the webbing into the pot or crib where they are trapped. This type of net or trap may be very simple or very complicated in construction. The simplest type is made by driving stakes of wood or metal into the shallow bottom to form a fence. At the deep end an enclosure is built of the same material. When sufficient fish have accumulated they are seined or dipped out. More elaborate traps are made of fiber webbing and may be suspended from driven posts, or may be self-suspending from buoys and anchors. Net traps are usually set in deeper water than the simple trap of wood and are raised to the surface to remove the fish.

Stream weirs are used to block off migrations. The weirs may be stakes driven into the bottom to direct the fish to a trap or removal pot. A simple stream weir used here in Syria consists of stakes driven into the ground at an angle. As the fish move downstream they come in contact with the slanted weir stakes and the current forces them up onto the slanted stakes where they are easily picked up by the fishermen.

There are two main types of entangling gear, the trammel net and the gill net. The trammel net is a flat net consisting of three separate webs. The two outer webs are of large coarse mesh and are called walls. They are equal to the depth of the net. The inner web is fine meshed and is usually about five times as deep as the outer webs. The three webs hang vertically from an upper or float line and have a lower or lead line. As the fish swims into this net it pushes the inner mesh through the outer web mesh which forms a pocket from which the fish cannot escape. Trammel nets are rather widely used along the Mediterranean Coast for sea fishes at the present time. However, the trammel net is considerably more costly and takes much more care in setting and in removing the fish than the straight gill net.

The straight gill net is a flat net with a single layer of webbing which is suspended in the water vertically from an upper or float line and a lower or lead line.

The gill and trammel nets may be set in many different ways, depending upon the species of fish sought. The three most common ways are the float or drift method, the stake set, and the anchor set. The float or drift method is the most common method for the trammel net. The net is set so that it floats at the surface, the lead line containing only sufficient lead weights to keep the net hanging vertically but not pulling it beneath the surface. The surface pelagic species may be caught in this way. The net floats or drifts in the wind and current.

A staked net is one suspended from stakes or posts, firmly imbedded into the bottom. It is principally used in bays and estuaries of rivers, in shallow lakes and in slow moving rivers.

An anchored net is one that is held in place by an anchor line. It can be used in deeper waters than the staked method.

Another method of fish capture is the encircling method. This method includes all types of nets which take fish by manipulating the net around a group of fish, or scoop them into the net, or are cast over the fish. In this group are the seines, dip nets, trawls, and cast or throw nets.

A seine is a flat net of considerably heavier cord than the gill nets and is made in many styles. Generally it has a cork or float line and a bottom line or lead line. The length may vary from one meter to 1,500 meters or more, and in depth from one meter to 30 meters. The seine may also be tapered so that the middle section is twice or more times the depth of the end sections. The beach seine is usually set from a boat with one end set near shore and the net let out in a circle so that the other end is brought in near the shore again, and then the net is pulled into the shore from both ends. Sometimes the seines are set from boats and pulled up to the boat away from the shore in open water.

The dip net is usually a large square of webbing attached by the four corners to ropes which are fastened to the end of a balanced pole. The net is lowered into the water and when fishes swim over it, the net is quickly lifted forming a pocket in which the fish are trapped.

Another form of dip net is a bag of netting fastened to a hoop on the end of a pole or sometimes is fastened between two poles. These are scooped through the water in an attempt to take fish.

The throw net is a light circular net somewhat bell-shaped with weights around the entire edge. It is cast over a school of fish and the weighted edges sink rapidly encircling the school. The net is hauled in by a line attached to the center. The weights bunching together at the base when it is hauled in prevents the fish from escaping.

As was stated earlier, there are many hundreds of variations to the nets described above. Each country or region has its own preference and adaptations. However, these adaptations should not preclude the trying out of new methods. In many instances the tradition of using a particular net results in a great deal of work and very little returns. As new methods and equipment are devised and proved useful, the fishermen should adopt them.

Once the fish has been captured, the problem of care and disposal becomes of utmost importance. The small operator who takes but a few kilograms at a time usually disposes of his catch in the immediate vicinity. With large operators, taking tons of fish at a time, the problem of care and disposal is a great one and thousands of dollars of equipment are needed. In this region our problem is one of medium sized operators who take up to one ton at a time.

At the present time in Syria the bulk of the fish taken are sold in a condition known as "in the round" or "whole". They are as they come from the water with all the intestines in them. The main problem of fish in this condition is one of freshness. The fish begins to deteriorate as soon as it is dead, and leaving the intestines in hastens the process of spoiling. This process of spoiling can be slowed down by the placing of the fish in ice boxes, but few fish in Syria are so handled. They stay for hours after capture in the bottom of the boats or in baskets and piles on the shore. When the fish are shipped to the larger cities, sometimes ice is added to the boxes, and in the city markets the fish are usually on ice. However, much spoilage has taken place and the fish have lost much of their freshness and have acquired tastes from the decomposition that has taken place.

It would be most desirable and probably should be required that the fisherman would immediately upon capture remove the intestines and put the fish on ice. This would greatly improve the quality of the fish and permit them to be held a longer time. A slightly higher price would be charged for the cleaned fish, but the buyer would still receive the same amount of meat for the same price, since he has to discard the intestines anyway, and has paid for these at a lower rate. If the fish were cleaned he would receive a much better product to eat.

The establishment of refrigerated store houses at the main centers of fishing to store small catches for two or three days until a full refrigerated truck load was available would be of great assistance to the fish trade. Small store houses made from local building materials could easily be built. These buildings should be lined with a waterproof material so they could be easily cleaned. By using these refrigerated store houses, it would make it profitable to invest in larger refrigerated trucks which in turn would reduce the costs of transportation. A truck taking two tons at a time is cheaper to operate than making four or five trips in a small pickup.

While there are methods of preservation such as deep freezing and canning, the quantities of fish taken in Syria do not warrant the use of such methods. Not a large enough quantity is taken to make a profitable business. It might be possible for a few small operators to set up a smoking plant and prepare some smoked fish, which do keep slightly longer than fresh fish, but again it is a question of local tastes. Some people do not like fish prepared in this manner.

It is believed that for the present, however, the Syrian fisherman and merchant should concentrate on getting their fish to the people in the freshest possible condition as described above. This can be done very easily and with the minimum of investment. Yet, if done, it is believed a better price may be obtained for the fish and the people will have a better product to eat.

It is further believed that if refrigeration is established at the main fishing centers that the fish production of Syria can be considerably increased. At present the fishing is limited to a few cold winter months. With refrigeration storage, the cleaning of the fish immediately upon removal from the water and immediate icing, fishing could be carried on most of the year. It is believed that the fish production in the main waters is not being utilized to its fullest extent. Indications are that considerable quantities of fish could be obtained especially in the late spring and early summer and in early fall, periods which are not now fished.

Experiments should be conducted on the use of different nets and other means of fish capture than are now in use.

The Fisheries Department should also make plans for supervising the commercial fishing. Regular statistical and reporting on catches should be made and a close check kept on the biology of the commercial species in order to regulate the catches. If this control is kept there should be little danger of overfishing or depletion of the stocks. On the other hand, constant check can also indicate the need for additional netting to prevent overpopulation and a slowing down of the optimum growth of the species. Proper management will insure the greatest number of fishes over the longest period of time.

In addition to the exploitation of the natural waters, there are some places in Syria where Fish Cultural stations could be established. Information on these places and methods for establishing and operating such stations may be found in the report on Fish Culture in Syria.

Chapter XIV

INSTRUCTIONS FOR COLLECTING DATA ON FISHERY BIOLOGY

It is essential that certain standard procedures be adopted in the collecting of field data, the maintenance of records, and in report preparation. Therefore, the following instructions have been prepared and they should be followed until further instructions are issued.

BIOLOGICAL DATA

I. Collecting Fish

The methods used in collecting samples of the fish population of a lake or stream will be determined by the water to be studied. Fish may be collected by gill nets, seines of various sizes, trapping in weirs, trap nets, fyke nets or electrical fishing devices. In streams, seining of typical areas (both pools and riffles) is one of the best methods. In lakes and larger rivers, gill netting, supplemented by seining, is probably the best. In brief, surveys and preliminary work, the use of the graduated mesh gill net (known generally as the experimental gill net) is recommended. If an intensive long-range study is made, the use of single mesh nets over the effective mesh range is probably the most satisfactory method. Other nets may be used in areas where experience has shown them to be effective.

Nets are to be set in the various habitats in the lake so that full coverage of the lake is obtained, since some species inhabit certain types of areas and not others (shoreline vegetation dwellers as compared to open water or deep water species).

The data asked for on the fish collection form should be filled in at the time of collecting. Where figures given are estimated, the letter E should be placed after the number given.

A sample of fishes should be preserved in 10% formalin (add 9 parts of water to 1 part of ordinary commercial formaldehyde, 38-40%). After a week in formalin the specimens should be transferred to water for at least two days to remove the excess formalin. The water should be changed at least once, then the fish should be put in 70% ethyl alcohol (or 40% isopropyl alcohol) for permanent keeping. Larger specimens (over 150 mm.) should be slit along the right side of the belly for about 3 centimeters to let the formalin into the abdominal cavity to preserve the intestine.

A label on strong waterproof bond paper should be put in each collection jar, giving the date, place of collection, collection number, and the collector. The writing on the label should be in soft lead pencil or waterproof ink.

II. Taking Fish Measurements and Scale Samples

Certain data should be taken from the specimens collected in order to determine fish production, condition of specimens, productivity of the water, age and growth rate, etc.

The following data are to be recorded on the length-weight record form or scale envelope, according to the situation.

Length: A measuring board should be obtained for the accurate measuring of the fish caught. The fish should be placed with its snout against the end board with just enough pressure applied to close the mouth into its normal position if it should be open, but not enough pressure to flatten out the snout and cause a distortion in measurement. Two length measurements may be taken, depending upon the needs of the study:

Total Length: From tip of snout with mouth closed to tip of the tail with lobes squeezed together. Record to nearest millimeter.

Standard length: From tip of snout with mouth closed to end of backbone (to structural base of caudal fin rays). Record to nearest millimeter.

Weight: Depending upon the balance used and size of fish, weight is given to the nearest gram or 5 grams.

Sex: Determine the sex whenever possible. This is usually difficult in small, immature fish. Record determination as ♂ (male), ♀ (female), or ? (not determined).

State of organs: This refers to sex organs. To standardize the classification of sex organs the following will be used:

During the SPAWNING season of a species, the organs will be classified as:

Immature - no visible eggs or milt

Mature - indicates eggs or milt present, but not ready for spawning. Slight pressure on abdomen does not release them.

Ripe - contain mature eggs and milt and are ready for spawning. Slight pressure on abdomen releases them.

Spent - fish have spawned.

During the remainder of the year, the fish will be classified as:

Immature - no visible eggs or milt.

Mature - eggs or milt present in some stage of development.

Gear: If collected by gill net, write in this space the mesh of the net in which the fish was caught, stating whether bar or stretched measure is used. Example: Gear 25 mm bar.

If collected by seine, write in S, then the length of the seine, then the mesh of the seine stating whether bar or stretched measure is used. Example: Gear S - 3 - 5 bar which indicates the fish were taken in a three meter long seine of five millimeter bar measure mesh.

LENGTH-WEIGHT DATA
معلومات عن الوزن والطـــــول

Lake or Stream الجدول أو البحيرة ______________ Date التاريخ ______________

Method of collection طريقة الصيد ______________ Collector الصياد ______________

Species الفصائل ______________

Sex الجنس	Weight الوزن	Length الطول	Sex الجنس	Weight الوزن	Length الطول	Sex الجنس	Weight الوزن	Length الطول	Sex الجنس	Weight الوزن	Length الطول

GILL NET RECORD

سجل شبكة الغلاصم

Location

المكان ______

Depth of set Date

التاريخ ______ عمق الغوص ______

Hours set Time lifted Time of set

مدة الغوص ______ زمن الرفع ______ ساعات الغوص ______

Net length Net mesh

عين الشبكة ______ طول الشبكة ______

Time Water Air : Temperature

الحرارة : الهواء ______ الماء ______ الزمن ______

Preceding Present : Weather

الطقس فى الحاضر ______ فى السابق ______

Turbidity Color : Water

الماء : لونها ______ عكورتها ______

Vegetation Type of bottom

نوع القاع ______ النبات ______

Field collection Number Collector

الصياد ______ الرقم الحقلى للصيدة ______

Numbers الأعداد	Sex condition الوضعية الجنسية	Size range معدل الحجم	Aver. Length معدل الطول	Species Collected الفصائل المصادة

SEINING RECORD
سجل الصيد بالطرحة

LOCATION
المكان ____________________

Date
التاريخ ____________

Gear Used
الشبكة المستعملة ____________

Length
الطول ____________

Mesh
العين ____________

No. of hauls
عدد مرات سحب الشبكة ____________

Type of bottom
نوع القاع ____________

relative abundance - Aquatic vegetation
النباتات المائية - كثافتها النسبية ____________

____

Air temperature
حرارة الهواء ____________

Water temp.
حرارة الماء ____________

Time
الزمن ____________

Turbidity
العكورة ____________

Field collection Number
الرقم الحقلي للصيدة ____________

Collector
الصياد ____________________

Species collected الفصائل المصادة	Size range مدى الحجم	Sexual condition الوضعية الجنسية	Numbers collected الاعداد المصادة

The mesh sizes are important in determining to what extent a given sample is representative of the total population and in reports the type of mesh measurement - bar or stretched - should always be stated.

Scale sampling: Eventually the age and growth rate of certain species of fish will be studied and some collection of scales can be taken in advance of these studies to provide increased numbers for study, as well as for additional years of reference when the final study is made.

The utmost care should be exercised to give all the information called for on the scale envelopes, being sure to take the scale samples as described below.

The scale sample should be taken from the left side of the fish just below, but not including the lateral line, on the anterior one-third of the body.

The scales are best removed by scraping with a scalpel. Remove the scales and place in the envelope, being sure that there are no scales adhering to the scalpel before taking the next sample.

III. Stomach Analysis Procedures

The techniques of stomach analysis used depend upon the results wanted. If only a general idea of what the particular species was feeding upon at the time immediately before capture is wanted, the simple removal and cutting open of the stomach and the cursory examination in the field is adequate. Notes can be recorded on a field data blank of the findings.

When a more detailed study is desired, several procedures can be used. Two will be described here, and in general will apply to the majority of stomach analyses work.

The field collecting techniques for both methods is the same.

1. Cut intestinal canal immediately behind the pharynx and in front of the anus. Remove with no effort being made to separate it from the liver and pancreas.
2. Wrap the entire mass in cheesecloth with label placed inside. Generally it is convenient to make a fold or two over the intestine before inserting the label. This will aid in keeping the label legible. On the label give: Species, length, weight, sex, location and collection number.
3. Preserve in 10% formalin

Laboratory Analysis for Carnivorous or Omnivorous Species

1. Remove from the formalin jars the number of packets which can be completed in a regular work period and soak in water for 24 hours. This will remove most of the unpleasantness of the formalin. Caution must be used not to leave samples in water longer than 48 hours or they will start deteriorating. A deformalizing solution also can be used very satisfactorily.

2. Place individual digestive tract in a petri dish or other suitable container and remove all foreign matter (fat, liver, pancreas, etc.)

3. Remove stomach, cut open, flush out organisms with bulb syringe or wash bottle. Some particles may still adhere to stomach walls and these should be picked carefully with forceps. Use as little water as possible in washing out contents.

4. Examine contents under dissecting microscope, separate, identify and enumerate organisms present.

5. Place the individual organisms or groups of organisms on a blotter for not over one minute to remove excess moisture.

6. After this brief drying, place the various individuals or group of individuals in a centrifuge tube containing 5 cc. of water and record volume displacement for each.

7. Compute the percentage of total volume of each organism or group present.

8. If there is a large amount of plankton present, pour sample into centrifuge tube and allow to settle for 15 minutes. Record the volume of plankton. Then dilute to 5 or 10 cc. and gently mix concentrate by inverting tube several times. With a 1 cc wide-mouth pipette immediately remove sample before plankters settle, and fill a Sedgwick-Rafter cell as for plankton analysis. Count organisms and multiply by dilution and record total numbers.

9. When volume of any organism is less than 0.1 cc. record as T. for trace.

10. Use symbol < 0.1 cc for less than 0.1 cc in grand total.

11. Fish found in stomachs should be identified if possible. Also measure to the nearest millimeter if whole.

12. A record sheet should be made out for each stomach examined, even if empty.

13. Under comments include such information as kind and number of parasites found, information as to abundance of winter or summer eggs of copepods, etc.

14. Preserve and label any organism not previously found.

15. Stomach contents are identifiable or not. Do not clutter up record form with question marks.

Laboratory Analysis for Herbivorous Species

1. Remove packets as in Number 1 above.

2. Same as Number 2 above.

3. Obtain a 2 cc. sample from the most anterior part of the intestine. In some cases the entire contents of the whole intestine will be needed and the sample will still not equal 2 cc.

4. Place 2 cc or entire sample if less than 2 cc in a centrifuge tube. Some packing may be necessary to remove air bubbles. A gentle stirring with a teasing needle should be sufficient for the purpose.

5. If 2 cc. sample is obtained, dilute to 10 cc. level. Stir and shake to break up any large clumps of some forms.

   If less than 2 cc. is obtained, dilute proportionately. For example, if a 1 cc sample is obtained, dilute to 5 cc; if 1.5 is had, dilute to 7.5 cc., etc. This will give a constant dilution of the concentrate.

6. With a 1 cc widemouth pipette remove a 1 cc. sample and place in a Sedgwick-Rafter cell as for plankton analysis and count organisms and multiply by dilution and record total number on record form.

Fish Stomach Analysis Record سجل تحليل معدة السمك

Species وع ______ Lake or Stream البحيرة أو النهر ______

Leng طول ______ Weight الوزن ______ Sex النوع ______ Date التاريخ ______

Gear هاز ______ Determined by محددة من قبل ______

لعضو Organism	عدد الانواع No. of Spec.	عدد الاجزاء No. of Indiv.	الحجم في سم٣ Vol. in cc.	النسبة ٪ للحجم % tot. vol.	العضو Organism	عدد الانواع No. of Spec.	عدد الاجزاء No. of Indiv.	الحجم في سم٣ Vol. in cc	النسبة ٪ للحجم % tot. vol.
حلقيات Annelida					تصفية الاجنحة Hemiptera				
لافقريات Mollusca					غمدية الاجنحة Coleoptera				
روبة الغشاء Entomostraca					حرشفية الاجنحة Lepidoptera				
خوة الغشاء Malacostraca					ذات الجناحين Diptera				
حشرات المائية Aquatic Insects					غشائية الاجنحة Hymenoptera				
ية ذباب مايو Ephemeroptera									
ية الرعاشات Odonata					مجمل الحجم Total Volume				
طبقة الاجنحة Plecoptera					السمك Fish				
صفية الاجنحة Hemiptera									
مدية الاجنحة Coleoptera									
Trichoptera					البرمائيات Amphibians				
ات الجناحين Diptera					الطحالب (الغا) Algae				
					النباتات الحية Higher Plants				
جمل الحجم Total Volume					البقايا الميتة Debris				
لعناكب Arachnida					اللاعضوية Inorganic				
لحشرات الارضية Terrestrial insects					النباتات Plant				
ات الذنب القافز Collembola					الحيوانات Animal				
مستقيمة الاجنحة Orthoptera									

7. Occasionally large clumps of algae and other vegetable matter will be injected. Estimate the percentage by volume this material makes up of the total and remove from sample and follow above procedure. This food material which cannot be counted should be considered separately and given only a percentage basis. Other countable items are expressed in percentage by numbers. Thus the sum of the percentage items counted will total 100%. For example, a carp sample was made up of 50% algal mass and 50% countable forms. Of the countable forms, cladocerans made up 90% and copepods 10%.

8. Stomach contents are either identifiable or not. Do not clutter up record form with question marks.

IV. Plankton Samples

Two methods of plankton sampling may be used, depending upon what information is desired. If the investigator is primarily interested in what organisms are making up the plankton population of the lake, and the general quantity of the plankton crop at the time of the survey, the QUALITATIVE method is recommended.

However, if the investigator is planning a long-range study of plankton, the abundance of each species, and at what depths they are found, and the total plankton production throughout the entire period of study of the lake, then the QUANTITATIVE method must be used.

Since for the present, it would appear that only the former method need be used, only it will be described. The quantitative method details when needed, can be found in standard textbooks.

Qualitative Method of Plankton Analysis

Two types of collections may be made with the plankton net: 1. Vertical and 2. Horizontal. In lakes over three meters deep it is recommended that the vertical haul be used.

In making the horizontal haul, row the boat only fast enough to keep the net fully extended and trailing just below the surface. Make hauls of lengths of 30 or 60 meters. Record length of haul. Follow steps 6 through 9 below.

In making the vertical haul, the following procedure should be followed:

1. Anchor boat and take depth sounding.
2. Permit boat to drift about 3 or 4 meters from the spot of depth sounding to avoid region of bottom disturbance.
3. Wash net, if previously used, by dipping in water, being careful not to have water overflow the top. Rinse bucket well also to remove plankton adhering to it from washing operation.
4. Subtract the length of the net from the depth sounding and lower net to that depth. Be careful not to permit net to touch the bottom as silt will spoil the count.
5. Haul net up at a steady rate of about 30 centimeters per second.
6. Drain all water, rinse sides of net with water from outside, if there appears to be plankton adhering to net. Place sample bottle under bucket and open valve.
7. Add 0.5 ml. of formalin (10%) for each 10 ml. of plankton and water.
8. Fill out a label and add to bottle. Give location, depth of haul, date, collection number and collector's name.
9. If plankton sample is to be kept for a long time or carried for a long distance, fill the bottle completely with preservative and water at the same rate as above (7).

Qualitative Laboratory Analysis for Plankton

1. Allow sample bottle to stand 24 hours undisturbed. Draw off excess liquid, being extremely careful not to agitate settled plankton. When sample appears to contain less than 15 cc of plankton, draw off excess liquid down to 15 cc, and empty into a centrifuge tube. Allow to settle for one hour and read and record the number of cc of plankton.

   If sample appears to contain more than 15 cc. of plankton, draw to nearest 15 cc more than sample, 30, 45, etc., and empty into one, two or more centrifuge tubes, and follow procedure mentioned above.

2. To determine the plankton production the following formula is used:

$$\frac{\text{cc of plankton in sample}}{0.01767 \times \text{length of haul in meters}} = \text{cc of plankton per cubic meter}$$

If the net used has a mouth diameter smaller or larger

QUALITATIVE PLANKTON ANALYSIS

التحليل النوعي للبلانكتن

Lake البحيرة ______ Date التاريخ ______

Time الزمن ______ Depth العمق ______ Wind الريح ______ Sky السماء ______

Vertical or horizontal عامودى أو أفقى ______ Depth or length of haul عمق أو طول الطرحة ______ Meters أمتار

Diameter of mouth of ne قطر فتحة الشبكة ______ cm. سم

Volume of plankton in sample حجم البلانكتن فى العينة ______ cc سم٣

Calculated volume of plankton per cubic meter الحجم المخمن للبلانكتن بالمتر المكعب ______ cc سم٣

Identification Record

سجل التعريف

Zooplankton البلانكتن الحيوانى	Est. Numbers الاعداد المقدرة	Phytoplankton البلانكتن النباتى	Est. Numbers الاعداد المقدرة

Identified by

عفت. قبلا ______

3. **Identification of plankters.** For qualitative identification fill a Sedgwick-Rafter counting cell with a uniform sample. This is accomplished by gently inverting the sample several times and with a widemouth pipette removing a sample before the plankters settle.

   Identify the plankters to the smallest unit of classification feasible and record in order of abundance on record form. As estimate of approximate numbers of each organism should be included, i.e.,

Daphnia	100 E
Cyclops	56 E
Bosmina	14 E
Diaptomus	6 E

   The estimate will prove useful for comparisons, especially in stomach analysis.

Care of net

After completing the day's work, the plankton net should be rinsed in clear water and hung up to dry. If the net becomes very dirty wash in lukewarm water with a small amount of soap powder and rinse thoroughly in clear water and hang up to dry.

Repair of small holes can be done by touching a small drop of household cement to each break. Dry thoroughly before using.

V. Aquatic Vegetation Analysis

Vegetation beds should be plotted on the map of the lake, using standard symbols for the types of vegetation found. These symbols are:

T for floating vegetation
/ for emergent vegetation
— for submergent vegetation

Vegetation stations should be numerous enough to give a good cross-section of the plants in the lake or stream. The exact number will have to be determined by the technician making the analysis according to his best judgment.

In lakes, a vegetation station 10 meters by 10 meters is suggested. In streams, 3 meter strips should be adequate.

For each species of aquatic plants found, record on the record form the information called for:

Depth range - give range in depth in which plant is found, i.e., 0.5 to 3 meters.

Relative abundance - use symbols as follows:

S - sparse, if only scattered plants are found

M - medium, if spaced 0.5 to 3 meters apart

D - dense, if closer together than 0.5 meters, of forming a closed mass.

Remarks: note whether plants are marl covered by placing a C in this column on the record form. Note also flowering, fruiting or budding of plants, using symbols: Fl - flowering; Fr - fruiting, and B - budding or winter buds.

If identification cannot be made in the field, specimens should be preserved for later study. The following procedure for collecting plants is recommended:

1. Select an average plant.
2. When possible, collect a plant with both flowers and fruit present, but take in vegetative condition if you cannot obtain it otherwise. Usually July, August and early September are the best months for obtaining specimens in the north temperate zone.
3. When possible, collect a part of the underground portions along with the top.
4. A large plant can be cut up and selected for preserving, or may be preserved in several folders, labelling each portion in order: a, b, c, d, etc. If portions are preserved be sure to put on label the total length or height of the plant and other pertinent information.
5. Place plant between folded sheets of newspaper.
6. Fill out label with all data and place with specimens. The collection number should be written on edge of newspaper in case label falls out so that it may be placed with proper specimen.
7. Place folded newspaper between blotters and place in press. Draw pressboards down tight.

AQUATIC VEGETATION RECORD

سجل النباتات المائية

Date التاريخ ____________ Lake or Stream الجدول أو البحيرة ____________

Remarks الملاحظات	Relative Abundance الغزارة النسبية	Depth Range مدى العمق	Species الفصيلة

B-budding, or winter buds; fr-fruiting; fl-flowering : Under remarks enter

تخضع للملاحظات التالية ؛ مزهرة مثمرة مبرعمة أو براعم الشتاء .

D-Dense; M-Medium; S-Sparse : Abundance /C-Covered with marl.

8. After collections have been under pressure 4 to 6 hours, or overnight, replace wet blotters with dry ones and insert corrugated ventilators between blotter (blotter, folder, blotter, ventilator, blotter, etc.). If specimens were very wet it may be necessary to replace blotters again the second day.

VI. Bottom Samples

In lakes use a 15 cm. square Ekman Dredge and take 4 samples per station. The number of stations for each lake will depend upon the size of the lake, the number of bottom types, the suitability of the bottom for sampling, and the time available for care for the samples.

The sample should be screened through the standard sieve provided and all organisms picked out. If identification and measurements are to be made in the field, the total volume (by water displacement in a centrifuge tube) is recorded as well as the number and kind of each organism.

If study is to be done later in the laboratory, the sample should be preserved in 80% alcohol, with a proper label for identification.

In streams, the bottom sample is usually taken with a square foot bottom sampler. The frame of the sampler is placed on the bottom with the net bag downstream. The bottom material to a depth of about 3 inches within the frame is gently lifted and deposited into the bag, making as sure as possible that none of the material loosened washes around the bag. If considerable soil is involved, the sample may be screened through the standard sieve. If little soil is in the sample, the sample should be placed in a bucket or white enamel pan, and the organisms picked out. Identification and measurements are carried out as described for lake samples.

Laboratory Procedure for Bottom Analysis

Generally a volumetric analysis by water displacement can be used. Should the number of organisms be too small for volumetric analysis, use number and percentage occurrence.

VII. Parasite Examination

A parasite examination record sheet should be made out for each important fish species of the water studied. Identification of some of the more common parasites can be made in the field. Specimens of those and of

BOTTOM FOOD ANALYSIS
تحليل الغذاء القعرى

Date
التاريخ

Lake or Stream
البحيرة او الجدول

Area of bottom sampled
المساحة المعاينة من القعر

Depth
العمق

Type of bottom
نوع القعر

Type of Dredge
نوع الجرافة

cc
سم³

Volume of Sample
حجم العينة

Vegetation
النبات

Numbers الارقام	Organisms in sample العضويات ضمن العينة

Determined by
حددت من قبل

PARASITE RECORD
سجل الطفيليات

Lake or Stream البحيرة أو الجدول ____________________

Species النوع ____________ Length الطول ________ Weight الوزن ________ Sex الجنس ________

Skin الجلد ____________ Pectoral : Fins الزعانف : الصدرية ____________

Pelvic البطنية ________ Dorsal الظهرية ________ Anal الشرجية ________ Caudal الذنبية ________

Gills الغلاصم ____________ Mouth Cavity تجويف الفم ____________

Orbit المحاج ____________ Eyeball كرة العين ____________

General Musculature الجهاز العضلي العام ____________________

Stomach المعدة ____________ Pyloric caecae الزوائد البوابية ____________

Intestine الأمعاء ____________ Rectum المستقيم ____________

Peritoneal Cavity التجويف البريتوانى ____________ Liver الكبد ____________

Gall Bladder الحوصلة الصفراوية ____________ Kidney الكلية ____________

Air Bladder الحوصلة الهوائية ____________ Testes, Ovaries الخصيتين ، المبيضين ____________

Pericardial Region المنطقة القلبية ____________ Stomach Surface سطح المعدة ____________

Intestine Surface سطح الامعاء ____________ Fresh جديدة ________ Preserved Specimen or أو عينة محفوظة ________

How taken? كيف أخذت ____________ Examined by فحصت من قبل ____________

the less common or unusual forms should be preserved for laboratory examination. Kill and fix the specimens in Bouin's solution, then preserve in 70% alcohol. Be sure to label completely.

Fill out the record sheet completely. Fill in every blank either with the kind and number of parasites found, or with NONE if none were found. If the organ or area is not examined draw a line through the blank to so indicate.

VIII. Egg Count

In life history studies and in fish management, the knowledge of the numbers of eggs produced by each species is essential. The number of eggs must be known if survival is to be estimated. The number of eggs produced is significant in fish culture in determining the number of fish required for brood stock.

Egg counts can be made in two ways. First, at the time of spawning when the eggs are fully developed and ready to be laid, the females can be captured and with pressure applied to the abdomen, the eggs can be forced from the body into a pan or jar for preservation and enumeration. If it is not necessary to save the female for some other purpose, the female can be killed and cut open and the eggs remaining after stripping operation can be added to those stripped from her. If the female cannot be killed, then the number of eggs must be considered to be approximate until such time as it is possible to determine the average quantity of eggs remaining after normal stripping operations.

The second method is to remove the entire ovary from the fish prior to full ripening. The closer to the time of full ripening it is possible to obtain the ovaries, the better it is for counting.

The most accurate enumeration of eggs is the actual count, but this can be very tedious and time consuming. When actual counts become impractical (as in species with very large numbers of eggs) approximate numbers can be obtained by one of the following methods.

Volumetric Method. Under this method there are two ways to make the egg counts. First, count the eggs in a sample of known volume (v) taken from the unknown lot. Such a sample may be measured by water displacement in a finely graduated cylinder and 10 or 20 cc should be adequate. Then measure the total volume (V) of all eggs in the unknown lot. The total number may then be estimated as follows:

$$X : n = V : v$$

where X is total number in the unknown lot
n is number in sample
V is total volume of all the eggs
v is volume in sample

The second method is to count out 100 eggs and measure the volume by water displacement. If the eggs are small, it may be well to count out 200 or even 300 eggs and obtain the volume. Then the entire sample is measured by displacement, and the total number of eggs would be calculated by the formula given above.

Gravimetric Method: In the gravimetric method there are also two ways of computing the number of eggs. First, weigh a definite portion of the sample, such as 1 or 2 grams, and then count the eggs in the sample. Determine the total weight of the whole lot of eggs and calculate on the basis of the sample count.

The second way is to weigh a known number of eggs, and then the total lot, and calculate the total number.

In the gravimetric system it is important to remove the excess moisture. This may be done by placing the eggs on blotting paper for a given length of time, or by spreading the sample in a large pan and allowing the eggs to be exposed to the air for a definite period of time, or in some cases the samples may be placed in a drying oven for a time.

Von Bayer Method. In 1910, Von Bayer prepared a table for determining the number of eggs per liquid quart based on the diameter of the eggs. A metal trough of known length, usually 150 mm is used. The groove in the trough is filled with a single row of eggs, and the number of eggs it takes are counted. The diameter of the eggs is determined by dividing 150 mm by the number of eggs. By referring to his chart the number of eggs per quart is found. These values may be changed into number per cc by dividing the number per quart by 946.4 (the number of cc per quart). By determining the number of cc of eggs in the sample by displacement, and multiplying the number found by the number of eggs per cc, the total number of eggs is found. Von Bayer's chart is reprinted in Lagler's Freshwater Fishery Biology.

Preserved Ovaries. When it is necessary to make counts from preserved ovaries, the following method may be used.

Measure the total volume of the ovaries by water displacement. Then obtain volumes of each of 3 sections, well-spaced, from the ovary. Then separate out and count the mature eggs from each ovary section, separating them from the immature eggs and tissues. Take volume of immature eggs and tissues and subtract from the volume of the sections to get volume of the mature eggs. Take the average results of the three (or sometimes more) counts and compute the fully developed eggs per cc and then for the complete ovary.

The count can also be made using the gravimetric method by weighing three samples from various parts of the ovary, counting the eggs as described above, and calculating the total numbers on a weight basis instead of volume.

CHEMICAL ANALYSIS

Chemical analysis will be restricted for the present to the tests for oxygen, carbon dioxide, phenolphthalein alkalinity, methyl-orange alkalinity, and pH. When other tests are found necessary, the methods employed can be located in standard textbooks.

One analysis should be made at each station in streams, except for impounded areas which are treated as lakes.

The exact number of chemical stations on a lake depends upon the type of lake and is left to the discretion of the analyst. On very small shallow lakes a surface and bottom sample might be entirely sufficient; on other lakes several samples between top and bottom may be needed to determine the chemical condition. On a larger lake, with many bays and depressions, many stations will be needed to cover all the major areas.

I. Oxygen (Winkler Method)

A. Equipment

125 ml glass stoppered bottles
250 ml Erlenmeyer flasks, marked at 100 ml capacity
5 ml pipette

If Barnes dropping bottles with plastic caps cannot be obtained for the first three reagents listed below, ordinary medicine droppers graduated to 0.5 ml can be used with standard bottles as described below.

B. Reagents

Manganous sulfate ($MnSO_4$)
Alkaline-iodide (KI-KOH)
Concentrated sulfuric acid (H_2SO_4)
N/40 sodium thiosulfate ($Na_2S_2O_3$)
Starch solution or thiodine solution

The above chemicals, except the sodium thiosulfate ($Na_2S_2O_3$) can be put in Barnes dropping bottles. If these bottles are not available the manganous sulfate and alkaline-iodide solutions should be stored in rubber-stoppered bottles, the sulfuric acid in glass-stoppered bottles. The sodium thiosulfate solution is usually kept in amber colored glass-stoppered bottles. It should be made up fresh every two weeks or at most three weeks. For preparation of the reagents see page 288.

C. Procedure

The first four steps must be performed in the field immediately after collecting the sample from the desired depth by use of a water sample bottle.

1. Collect sample into 125 ml glass-stoppered bottle by gently flowing water into bottle without any splashing or bubbling. Allow water to overflow at least 20 seconds after it is filled.

2. Add 0.5 ml manganous sulfate ($MaSO_4$) and 0.5 ml of Alkaline-Iodide (KI-KOH) well below the surface. Restopper and mix by inverting bottle several times, being sure stopper is held in place.

3. Allow precipitate that forms to settle.

4. When settled, remove stopper and add 0.5 of concentrated sulfuric acid (H_2SO_4). Restopper and mix. If sample is adequately stoppered it may now stand several hours without change in oxygen content.

5. Rinse an Erlenmeyer flask with a small amount of the sample - then fill to the 100 ml line (or transfer 100 ml, using a graduated cylinder for the measuring). Titrate with 0.025 solution (N/40) of sodium thiosulfate ($Na_2S_2O_3$), rotating sample to insure mixing, until color becomes a pale yellow.

6. Add starch solution to produce blue color, or if thiodine is used add enough powder to produce the blue color.

7. Continue titration until blue color first disappears.

8. Record total amount of sodium thiosulfate used and ignore any return of blue color.

D. Calculations

To express results in parts per million (ppm) of dissolved oxygen - multiply ml of $Na_2S_2O_3$ used by 2.

E. Conversions

1. 1 part per million (ppm) = 1 milligram (0.001 grams) per liter

2. ppm x 0.698 = milliliters (ml) per liter

3. ml per liter x 1.43 = ppm or mg/l.

4. To express results as percentage of saturation
   (i) determine from Table 1 below the saturation value at sea level for the temperature of the water when the sample was collected.

Table 1. Saturation value of oxygen in fresh water at standard pressure

Temp. oC.	Oxygen ppm or mg/l	Temp. °C.	Oxygen ppm or mg/l	Temp. °C.	Oxygen ppm or mg/l
0	14.62				
1	14.23	11	11.08	21	8.99
2	13.84	12	10.83	22	8.83
3	13.48	13	10.60	23	8.68
4	13.13	14	10.37	24	8.53
5	12.80	15	10.15	25	8.38
6	12.48	16	9.95	26	8.22
7	12.17	17	9.74	27	8.07
8	11.87	18	9.54	28	7.92
9	11.59	19	9.35	29	7.77
10	11.33	20	9.17	30	7.63

(ii) Then multiply this value by the appropriate factor from the next table (Table 2) based upon the altitude of the body of water sampled.

Table 2. Correction factors for oxygen saturation values according to altitude in meters.

	0	100	200	300	400	500	600	700	800	900
0	1.000	0.987	0.975	0.963	0.951	0.939	0.928	0.916	0.904	0.893
1000	0.883	0.872	0.862	0.851	0.841	0.830	0.820	0.809	0.800	0.791
2000	0.782	0.772	0.763	0.754	0.745	0.737	0.728	0.718	0.709	0.701
3000	0.693	0.686	0.678	0.670	0.662	0.654	0.646	0.638	0.632	0.624
4000	0.617									

(iii) The percentage saturation (excluding Hydrostatic pressure) of the sample is then equal to

$$\frac{\text{observed } O_2 \text{ content}}{\text{saturation value at particular temperature and altitude}}$$

II Carbon dioxide

A. Equipment

100 ml Nessler Tube, (or 100 ml graduated cylinder)

B. Reagents

Phenolphthalein Indicator
N/44 sodium hydroxide (NaOH)

C. Procedure

1. Draw 100 ml of the sample into a Nessler tube or tall graduate cylinder being careful not to splash sample since agitation releases carbon dioxide.
2. Add 10 drops of phenolphthalein indicator
3. If sample turns pink, record as 0.0 CO_2
4. If sample remains clear, titrate with N/44 sodium hydroxide (NaOH), until weak pink color remains for a minimum of 30 seconds
5. Record number of milliliters of sodium hydroxide used.

D. Calculations

1. 10 times the number of ml of N/44 NaOH used equals the amount of carbon dioxide in parts per million
2. Conversions from ml/l to ppm:

Multiply	By	To obtain
ppm of CO_2	0.506	ml/l
ml/l of CO_2	1.98	ppm

III. Alkalinity

A. Equipment

250 ml Erlenmeyer Flask
5 ml pipette

B. Reagents

Phenolphthalein indicator
Methyl-orange indicator
N/50 sulfuric acid

C. Procedure

1. Draw 100 ml of sample water into flask or bottle.
2. Add 4 drops of phenolphthalein indicator.
3. If sample remains clear, record as 0.0 ph-th (Phenolphthalein) alkalinity, and proceed with step 5.
4. If sample turns pink, titrate it with 0.02N (N/50) sulfuric acid (H_2SO_4) from a burette, until pink color just disappears. Titration should be done against a white background for better color perception. Record amount of acid used as P.
5. To same sample, add 4 drops of methyl-orange indicator.
6. If sample turns orange (often expressed as salmon color), record as 0.0 methyl-orange alkalinity.
7. If sample becomes yellow, titrate with 0.02 N (N/50) sulfuric acid until it turns faint orange. Sample should be rotated after each few drops to insure mixing. Record amount of acid used as M.

D. Calculations

1. Symbols and terms

P = No. of ml N/50 H_2SO_4 used in titration with phenolphthalein

M = No. of ml N/50 H_2SO_4 used in titration with methyl-orange

T = Sum of P and M; i.e., the total number of ml N/50 H_2SO_4 used in the total titration.

(Obviously, if step 4 above is omitted as a result of no color change in step 3, then T = M).

In the calculation that follows one uses only P and T. From these one can determine and express in parts per million of calcium carbonate either:

(i) "phenolphthalein alkalinity" = P x 10

(ii) "total alkalinity" (also known as "methyl-orange alkalinity") = T x 10

2. Conversions and Interpretation of Alkalinity Relationships

a) Conversion to SBV

To convert the "total" or "methyl orange alkalinity" (as expressed in ppm of calcium carbonate) - into a value equivalent to the "SBV" used by some workers - divide it by 50.

To convert "SBV" into the total or methyl-orange alkalinity (as expressed in ppm of calcium carbonate) - multiply it by 50.

b) Interpretation of Alkalinity Relationships

When desired, one can make further differentiations of alkalinities due to hydroxide (OH), normal carbonate (CO_3) and bicarbonate (HCO_3), using Table 3 below for mathematical conversion of results.

According to this scheme:

(i) Carbonate alkalinity is present when the phenolphthalein alkalinity is not zero but is less than the total alkalinity,

(ii) Hydroxide alkalinity is present if the phenolphthalein alkalinity is more than one half the total alkalinity,

(iii) Bicarbonate alkalinity is present if the phenolphthalein alkalinity is less than one half the total alkalinity.

Table 3. Mathematical conversion of results

Result of Titration	Alkalinities expressed as ppm of calcium carbonate		
	Hydroxide	Carbonate	Bicarbonate
$P = 0$	0	0	$T \times 10$
$P < \frac{1}{2}T$	0	$2P \times 10$	$(T - 2P) \times 10$
$P = \frac{1}{2}T$	0	$2P \times 10$	0
$P > \frac{1}{2}T$	$(2P - T) \times 10$	$2(T - P) \times 10$	0
$P = T$	$T \times 10$	0	0

SBV (Säurebindungsvermögen) known variously as acid combining power, alkaline reserve, etc., is expressed simply as the total number of milliliters of N/10 HCl or H_2SO_4 required to titrate 100 ml of a water sample using methyl orange as an indicator.

IV. pH

A. Types of pH equipment

Generally there are two kinds of methods for measuring the pH (hydrogen ion concentration) of the water: 1 Colorometric and 2 Electrometric.

Colorometric methods depend on the addition of sensitive indicator solutions, to the sample and making comparison with a set of standard colors of known pH values. There are also available sensitised papers which when dipped in the sample water change color. This color is then checked against the standards for the pH value.

Electrometric methods are also of several types depending on the apparatus purchased. Usually this method is confined to laboratory work because of the rather delicate nature of the electric equipment, although some companies do have portable battery operated field equipment.

B. Procedure

The procedure for making the pH determination is given with each set of equipment. Follow the directions as given with the set available to the worker.

V. Preparation of reagents

1. Manganous sulfate solution (for O_2 determination)

1.1 Dissolve in distilled water and make up to 1 liter one of the following quantities:

480 g $MnSO_4 \cdot 4H_2O$, or
400 g $MnSO_4 \cdot 2H_2O$, or
364 g $MnSO_4 \cdot H_2O$

2. Alkaline-iodide reagent

2.1 Dissolve in distilled water and make up to 1 liter one of the following combinations:

500 g NaOH and 135 g NaI, or
500 g NaOH and 150 g K I, or
700 g KOH and 135 g NaI, or
700 g KOH and 150 g K I.

3. Sulfuric acid, concentrated

3.1 Specific gravity, 1.83 to 1.84
About 36 N

4. Sodium thiosulfate solution, N/40 (0.025 N)

4.1 Dissolve 6.205 g $Na_2S_2O_3$ - $5H_2O$ in freshly boiled and cooled distilled water and make up to 1 liter. Add 5 ml chloroform ($CHCl_3$) or 0.4 g NaOH per liter as a preservative. Store in brown bottle. Make up a fresh solution every two or three weeks.

5. Starch solution

5.1 Grind up 5 g of potato or arrowroot starch in a small quantity of distilled water. Pour emulsion into 1 liter of boiling water, stir and leave to settle overnight. Decant the clear portion. Add 1.25 g salicylic acid as a preservative or a few drops of toluene.

6. Phenolphthalein indicator

6.1 Dissolve 5 g of high-quality phenolphthalein in 1 liter of 50% ethyl alcohol; then add N/50 (0.02N) NaOH dropwise until a faint pink color appears. (Prepare the 1 liter of 50% alcohol by diluting 526 cc of 95% alcohol to one liter with boiled distilled water).

7. Methyl-orange indicator

7.1 Dissolve 0.5 of high-quality methyl orange in one liter of distilled water. Keep in dark glass bottle.

8. Sulfuric acid, N/50 (0.02N)

8.1 Transfer 10 ml concentrated H_2SO_4 to a volumetric flask and make up to 1 liter with distilled water. The resulting solution is approximately 0.36N. To make up a N/50 solution from this stock solution, transfer 55.56 ml to a volumetric flask with a burette and make up to 1 liter.

WATER ANALYSIS

Lake or Stream

البحيرة او الجدول ______________________________

Sechi Disk عمق نفوذ الضوء	Water Color لون الماء	Preceding weather حالة الطقس السابقة	Wind dir. Vel. اتجاه وسرعة الرياح	Sky السماء	Air temp. حرارة الهواء	Time الزمن	Date التاريخ	Station Number رقم المركز

pH الحموضة	MO مثيل الاورنج	ph-th فينو فثالين	CO_2 ثاني اوكسيد الكربون	O_2 الاوكسيجين			Bottle Number رقم الزجاجة	Temperature درجة الحرارة	Depth Metres العمق بالامتار
				O_2ppm. اجزاء الاوكسيجين بالمليون	Factor العامل	Thio cc. ثايو سلفات بالسم			

To standardize, place 20 ml N/44 Na_2CO_3 (see below) in a casserole or Erlenmeyer flask over a white background and add 5 drops of methyl-orange indicator. Titrate with the dilute acid until the color begins to change from yellow to red. The normality factor of the N/50 acid is the number of ml of acid used divided into 22.73.

9. Sodium carbonate, N/44

Heat chemically pure sodium carbonate in an open casserole over a bunsen burner for ½ hour to convert any bicarbonate present into carbonate. When cool weigh out 1.205 g and dissolve in recently boiled distilled water, making up to one liter. This gives a N/44 solution. Because alkaline solutions such as these rapidly absorb CO_2 from the air thereby altering their normality, they should be kept tightly stoppered, or in bottles having CO_2 traps.

PHYSICAL ANALYSIS

I. Map

It is assumed that maps of the waters are available. If this is not the situation, then the party will make a map of the lake following the standard procedures for mapping.

II. Depth of Water and Bottom Type

If depth contours are not provided on the map, the party will proceed with this phase of the work, again following standard methods.

If bottom types are not recorded on map of the lake, the party will proceed to fill in this phase of the work also. Again standard techniques will be used. The classification of soil types is given later.

In stream surveys, average width and depths will be recorded as described below under rate of flow.

In stream surveys, bottom types will be described for pools and riffle areas in the section studied. Record the estimated percentages as called for on the record form.

The types of bottom soils are defined as follows:

Marl - deposit of calcium carbonate. It may be concretion marl, shell marl (abundance of shells and shell fragments) or amorphous marl (uniform, relatively pure marl which clouds the water when disturbed).

Mud - a more or less compact mixture of clay and other soils.

Silt - a soft, flocculent, finely divided soil.

Clay - a dense, compact, sticky and smooth soil. When dry it forms a hard clod difficult to break. When moist, it is sticky and plastic, when squeezed it does not crumble, but works into a heavy, compact mass.

Sand - loose, single grained soils, gritty. Individual grains can be felt and seen.

Detritus - Composed of more or less finely divided organic material, such as bits of leaves, twigs, bark, remains of water plants, etc. It is frequently found on the pool bottoms, or in the shelter of any obstruction to the current in streams.

Muck - black, completely decomposed organic material.

Peat - brownish to greenish, partly decomposed plant remains. It may be in the form of fibrous peat (coarser, herbaceous material, parts of plants relatively easily distinguished) or as pulpy peat (uniform fine texture, parts of plants not distinguishable).

Hardpan - consists of hard deposit of clay which has been exposed by water action.

Gravel - individual particles ranging in size from about 2 mm to about 50 mm in size.

Rubble - individual stones from 50 mm. in size up to about 300 mm.

Boulder - each stone above 300 mm in diameter.

Bedrock - solid underlying layer of stone.

III. Temperature

For a beginning it is suggested that a maximum-minimum thermometer be used for the needed temperature data.

This thermometer should be lowered to the proper depth and allowed to remain 3. to 5 minutes before being hauled to the surface.

Temperatures should be taken at 1-meter intervals. If a thermocline is indicated, temperatures at 1/3rd meter intervals should be taken to limit the extent of the thermocline. Later, if it is deemed necessary for further detailed study of deeper lakes and reservoirs, a reversing thermometer or an electrical resistance thermometer can be acquired and put into operation.

In taking stream temperature, an ordinary thermometer is used. Temperature of the air is taken first, while standing with the sun to the back holding the thermometer an arm's length from the body at waist level, with the bulb in the shade of the body. Four or five minutes should be allowed for the registering of the air temperature before reading and recording it. The bulb must be absolutely dry.

The water temperature is taken by inserting the thermometer bulk below the surface of the water, allowing 1 to 2 minutes for registering of the temperature, and then reading the temperature with the bulb still in the water.

The hour and weather conditions should be recorded on the record form as called for.

IV. Turbidity

Secchi Disk. The Secchi disk will be used for all determinations of turbidity in the lakes for the present. The readings should be taken as near to noon as possible. Notation should be made as to the degree of cloudiness and the amount of wind and wave action.

The reading is obtained by lowering the disk slowly into the water, noting the depth at which it disappears from view, and then slowly raising the disk until it again appears in sight. The average of these two readings is recorded as the limit of visibility.

In depths less than 1 meter, record to the nearest centimeter.

In depths more than 1 meter, record to the nearest 5 centimeter mark.

Record the cause of the turbidity: i.e., plankton bloom, muddy water, etc.

In streams, the Secchi disk is used only in deep pools, or when and where the bottom is not visible. Other times the ocular estimate is used.

Ocular Estimate. For ocular estimates of turbidity, classify the water as clear, murky, or muddy.

Estimates may be made as follows:

Clear - bottom visible through more than 1 meter of water
Murky - bottom indistinct in 1/3rd to 1 meter deep
Muddy - bottom visible in less than 1/3rd meter.

V. Color

Express color of water as white, light brown or dark brown. The majority of waters are white, although occasionally lakes and streams draining marshes and swamps will show brown color.

Occasionally pollutant materials will stain the water in which case record the color.

Care must be taken to make sure the color is true color and not apparent color due to suspended material in the water.

VI. Stream Flow

Average width and depth. A series of measurements is made of the stream station. At least five measurements should be taken of the width of each station; each end, middle and midway between these are usually taken. More measurements should be made if the stream is particularly uneven. The average is then obtained.

Depth is measured at points of width measurement. Depth is taken in the middle of the stream, and at a point halfway between the middle and each shore. If the stream is wide or the bottom uneven, more than the three soundings should be taken. The average depth is determined by adding the readings and dividing by one more than the number of soundings taken. This allows for the zero readings at the shore.

Volume. Volume will be recorded in cubic meters per second where the flow is greater than 1 cms. Flows less than 1 cms should be given in liters per minute (lpm).

The following formula is used to determine the volume flow:

$$R = \frac{W \; Da \; L}{T}$$

Where R is rate of flow

W is average width of section

D is average depth of section

T is average time in seconds required for a float to traverse the distance L.

L is the length of the stream section

a is a constant for correction of stream velocity. If the bottom is rough and strewn with rocks and coarse gravel, a is taken as 0.8, if the bottom is smooth a is taken as 0.9.

As straight a section of stream as possible is selected for this test. Measure the length, width and average depth of this section. Then time the length of time it takes for a small float (about the diameter of a lead pencil and 75 mm long) to traverse the distance. Three trials should be run with the float and the average time used.

Substitute the proper figures in the formula and determine the volume flow.

Velocity. Velocity may be described in terms of centimeters per second flow according to the following table:

very slow	-	0-10 cm. per second
slow	-	11-25 " " "
moderate	-	26-50 " " "
moderately rapid	-	51-75 " " "
rapid	-	76-100 " " "
very rapid	-	101-200 " " "
torrential	-	201 and above

VII. Pools and Shelter

In some stream studies it is desirable to know the amount of the stream bed in pools and in riffles. This may be done by measuring off about 100 meters of the stream and studying the pools and riffles according to size, type and frequency. Determine which of the following conditions most nearly applies to the pools found in the section and record data on record form using symbols presented after the following description of conditions.

Size 1. Pools having an average width or length much greater than the width of the stream.

2. Width and length equal to width of the stream.

3. Much narrower or shorter than the stream width

Type 1. Deep (2/3rd meter or more), exposed pools containing great amount of aquatic plants harboring a rich fauna; or deep pools with abundant shelter (overhanging banks, logs, roots, boulders), much drift and detritus shaded by forest cover or shrubs.

2. Pools intermediate in depth, shelter, plant abundance, etc.

3. Shallow exposed pools without shelter or plants, scoured basins.

Frequency 1. More or less continuous pools - about 75% to 25% relation of pools and riffle areas.

2. Rather close succession of pools and rapids - 50-50%.

3. Pools infrequent with long stretches of swift, shallow water between, pools making up less than 25% of the total stream area.

In recording information use S for size, T for type and F for frequency. Thus the highest rating for a stream would be S - 1, T - 1, F - 1. The poorest rating would be S - 3, T - 3, F - 3.

The factors responsible for the pools at each station should also be listed i.e., whether caused by boulders, logs, undercut banks, or simply by the cutting action of the streams. Under shelter, indicate the abundance of water plants, rocks, sunken logs, or whatever form of protection for fish is afforded by the pool.

STREAM SURVEY

معاينة جداول المياه

Main drainage Name of Stream

اسم الجدول ______ الحوض الرئيسى ______

Stream Section

جزء الجدول ______

wooded, open, swampy, flat , rolling: Watershed

طبيعة المجرى متقلب ، منبسط ، فسق ، مفتوح ، مشجر

mountainous, hilly, Cultivated or not

مزروع أم لا ، جبلى ، هضى

Bank Vegetation

نبات الضفاف ______

Abundant Common Rare Algae-aquatic vegetation

غلفق ، النبات المائى ______ نادر ______ شائع ______ كثير ______

Abundant Common Rare Higher plants

النباتات المعطية ______ نادر ______ شائعة ______ كثيرة ______

Irrigation pumps, diversions, barriers, dams

حدود ، حواجز ، قواطع التحويل ، مضخات للرى ______

Pollution

التلوث ______

High water level Present level Water Supply

احتياطى المياه المستوى الحالى ______ مستوى المياه المرتفع ______

Steep Moderate Slight Gradient

الانحدار خفيف ______ متوسط ______ قوى ______

Frequency Type Size Pools

الاحواض الحجم ______ النوع ______ التعداد ______

Abundant Common Few None Spawning areas

امكنة التفقيس منعدمة ______ قليلة ______ شائعة ______ متعددة ______

______ % Gravel ______ %Rubble ______ %Bedrock : Stream Bed

مجرى الجدول % صخور تعرية % ______ حجارة % ______ حصاء % ______

______ % boulders ______ % Silt ______ % Mud ______ % Sand

رمل % ______ وحل % ______ طمى % ______ احجار كبيرة % ______

Fish Present

الاسماك الموجودة ______

Average depth Average Width

معدل العرض ______ معدل العمق ______

Velocity Volume Flow

حجم التدفق ______ السرعة ______

Water Temp. Air Temp. Turbidity Color

اللون ______ العكورة ______ حرارة الهواء ______ حرارة الماء ______

ph-th MO Alkalinity CO_2 O_2 pH

الحموضة ______ اوكسجين ______ ثاني اكسيد الكربون ______ القلوية ______ مثيل الاورنج ______

ph-th

فينوفتالين ______

Investigator

القائم بالبحث ______

FAO FISHERIES BIOLOGY TECHNICAL PAPERS

(issued since January 1962)

FB/T14	Handbook on fish culture in the Indo-Pacific region	Feb. 1962
FB/T18	Fish farming methods in the Philippines, Indonesia and Hong Kong	March 1962
FB/T19	World list of periodicals for aquatic sciences and fisheries, Vol. I	March 1962
FB/T10 (Rev. I)	A world list of experts concerned with the study of the biology of tunas and related species	April 1962
FB/T20	List of marine research institutes in the tropics (30° N to 30° S)	June 1962
FB/T7-Suppl. I	A list of experts concerned with the study of algae - Supplement I	June 1962
FB/T16 (Rev. I)	A bibliography of research on tunas for the years 1957-1962	June 1962
FB/T21	The effects of current eddies on the distribution of plaice eggs	June 1962
FB/T23	A bibliography of research on tunas for the years 1954-1956	June 1962
FB/T24	Fisheries oceanography	July 1962
FB/T8	The freshwater fishes of Syria and their general biology and management	Sept. 1962